Economic Potential of Mining in Manitoba: Developing Taxation Policy

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Foreword

The government of Manitoba commissioned CRS to undertake an assessment of taxation policy as it relates to mineral exploration, mining and processing. The resulting study compared the economic potential of the industry in Manitoba under different sets of conditions and different taxation measures. The conclusions were helpful in designing the revisions to the Manitoba mining act proposed in the 1992 provincial budget. This working paper presents the findings of the Manitoba report, plus updated data and analysis, in the hope that other jurisdictions will find it useful.

Views expressed are those of the authors, and do not necessarily represent the views of the Centre for Resource Studies or its sponsors, or of the Government of Manitoba.

Moira Jackson
Centre for Resource Studies

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All of this assistance is very much appreciated and gratefully acknowledged.

Executive Summary

Study Terms of Reference

The objectives of the study are to

- assess the economic potential of mining in Manitoba;
- analyze the impact of current mining taxation policy in Manitoba;
- examine Manitoba's competitive tax position in Canada;
- investigate the effects of several tax options on Manitoba's interprovincial standing;
- consider the impact of changes proposed in the March 1992 Manitoba budget.

The Manitoba database for this appraisal includes $1.1 billion of exploration expenditures, and deposit-specific estimates for 56 base metal, gold, and nickel deposits discovered during the 43-year period 1946-88 as a result of those expenditures. The study methodology assesses this experience in the context of present-day economic and technological conditions. Two types of economic assessment are made:

- long-term appraisal of the economics of investing in mineral exploration;
- medium-term appraisal of the economics of investing in new mine development.

Economic Potential of Mining in Manitoba

The economic potential of mineral exploration and mine development is shown to be substantial. For anticipated future conditions, long-term potential, measured from the start of exploration, is characterized by an expected value of $57 million for each economic deposit discovered. Medium-term potential, measured from the start of mine development, is typified by a net present value of $165 million per economic deposit. The enhancement in potential value which occurs between exploration and development, $108 million on average for each economic deposit in this case, illustrates exploration's economic contribution to mining in Manitoba.

The representative characteristics assessed for mineral exploration and mine development in Manitoba, as summarized above, are broad generalizations across a wide range of experience. Several other more specific features are also highlighted:

- a high degree of variability is found in the return characteristics of economic deposits around the composite values appraised. For example, a 48-fold difference in net present value occurs between the lower-decile and upper-decile economic deposits ($8 million and $380 million respectively around the mean value of $165 million);

- a marked deterioration in economic performance is evident within the 1946-88 study period, reflecting the effects of depletion in the Flin Flon and Snow Lake areas, and in the Thompson nickel belt. New strategic directions for mineral exploration are called for during the 1990s to counter and reverse the negative historical trends;
- the economic potential of exploration and development is found to be particularly sensitive to future metal prices. Flexibility should therefore be incorporated into government plans and policies to accommodate the resolution of price uncertainties with time.

Impact of Taxation

Manitoba's taxation policies are shown to have a substantial negative impact on investment incentive. For example, given anticipated future conditions, the expected value of exploration per economic discovery is reduced from the potential value of $57 million to $25 million after tax. The expected net present value associated with mine development is likewise reduced from $165 million potentially to an after-tax value of $77 million per economic deposit.

The Manitoba tax system also is found to be very inefficient. Under anticipated future conditions, one-sixth of the potentially economic deposits are rendered uneconomic by taxation. The effective tax rate in Manitoba is in the order of 55 percent, the provincial government collecting about 65 percent of the total tax revenues.

Manitoba's Competitive Tax Position

Interprovincial comparisons show that the level of mining taxation in Manitoba is substantially higher than in other Canadian jurisdictions, particularly with respect to provincial mining tax. While there is a high degree of interprovincial variation, the overall tax level in Manitoba is found to be about 20 percent higher than elsewhere. More specifically, the high level of Manitoba mining tax results in average tax revenues in the order of 40 percent above those which would be collected in the other Canadian provinces and territories. Two main factors explain these findings:

- allowable deductions are more restricted and nominal tax rates are higher in Manitoba than elsewhere in Canada;
- the Manitoba tax system is relatively inefficient, discouraging the development of a greater number of the potentially economic deposits.

Manitoba Mining Tax Options

With a view to improving Manitoba's tax standing in Canada, the following six tax options are examined:

- direct assistance to cover 25 percent of exploration expenditures;
- three-year tax holiday for new mines;

- 150 percent write-off of exploration expenditures;
- increase in the rate of depreciation from 20 to 30 percent;
- reintroduction of the 15 percent minimum processing allowance;
- depreciation rate of 100 percent.

A notable improvement in competitive position is evident for all options, although the incentive effect varies through a wide range. The three-year tax holiday and the 100 percent depreciation rate also would improve the efficiency of the Manitoba tax system.

The three-year tax holiday is found to provide the greatest incentive, reducing the level of provincial mining taxation by about 36 percent, and the overall tax burden in Manitoba by about 13 percent. For example, the long-term overall effective tax rate under anticipated future conditions would be reduced from 55 percent to 47 percent. This incentive program would close the existing competitive gap between Manitoba and the other Canadian jurisdictions. However, even with this incentive in place, Manitoba would still stand at the high end of the interprovincial range of tax levels.

Proposed Amendments to Manitoba Mining Tax

Two major changes to Manitoba mining tax were proposed in the March 1992 budget:

- a mining tax holiday for new mines;
- a 150 percent deduction of exploration expenditures that exceed the average exploration expenditures in the previous three years.

This incentive package incorporates parts of three of the individual options examined. These proposed changes would result in a considerable reduction in the level of tax payments collected. From the start of exploration, these amendments would lower the level of provincial mining tax by about 41 percent and the overall tax burden for mining in Manitoba by about 16 percent.

Manitoba's competitive position would be also significantly enhanced by the proposed changes. From the start of exploration, the Manitoba mining tax level of 59 percent would be very close to the overall average (58 percent) across the other Canadian jurisdictions.

Conclusion

A process of information assembly and analysis is necessary to support mineral-policy decisions. In this study, we have applied an empirical evaluation procedure to assess the economic potential of mining in Manitoba. This assessment is used to examine the impact of current mining taxation policy in Manitoba and the province's competitive tax position in Canada.

The individual tax options analyzed provided the basis for considering possible directions for Manitoba taxation policy. These results played a very useful role in the formulation of proposed tax amendments in the March 1992 provincial budget. These proposed changes are shown to greatly enhance the province's competitive tax position and the investment climate for wealth-creation in the Manitoba mineral sector.

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1. Introduction

Background

A process of information assembly and analysis is necessary to support mineral-policy decisions. If the support process is to respond efficiently to policy needs, several basic components must be present:

- an evaluation procedure to assess the potential value of mineral supply;
- an empirical database that documents mineral exploration, development, and production activities within the jurisdiction concerned;
- on-going capability to integrate the database and the methodology to produce economic assessments;
- an appraisal of the direct effects of mineral policy options on the potential value of mineral supply.

Mineral exploration and mine development are integral parts of the mineral supply process. The discovery and delineation of economic deposits – the successful result of exploration – is the necessary starting point for mine development. These two types of activity represent, respectively, the long-term and medium-term phases of the supply process.

While exploration and development are directly connected, their economic characteristics are quite different and should be clearly distinguished. Perhaps because of this, experience suggests that the size and type of organization best suited for mineral exploration may be different than the corporate requirements for successful mine development.

Government policy analysis normally tends to focus on a *typical* economic deposit at the mine development stage. Appropriate policy options are overlaid on the typical deposit profile, and their direct economic effects are evaluated and analyzed.

This standard approach is deficient in three important respects. First, the typical deposit profile is, as a matter of convenience, invariably based on an actual deposit situation rather than being synthesized from the characteristics of all economic deposits. Second, the variability in economic potential among deposits is not considered. Third, the exploration activity required as a prerequisite for mine development is ignored.

For realistic government policy analysis, these three features must be examined. An average or expected deposit profile can only be objectively determined as a composite of all economic deposits. This procedure also provides the basis for appraising economic effects associated with the variability of potential value among deposits. Finally, in the long term, the economics of mineral supply must be assessed from the start of exploration.

Objective and Scope

The study has five main objectives:

- to assess the economic potential of mining in Manitoba;
- to analyze the impact of current mining taxation policy in Manitoba on the economic potential assessed;
- to examine Manitoba's competitive tax position in Canada;
- to investigate the effects of possible tax options on this competitive tax position; and
- to consider the impact of changes in mining taxation proposed in the March 1992 Manitoba budget.

The study assesses both the long-term attractiveness of mineral exploration and the medium-term economics of investing in new mine development. Attention is focused throughout on base metal, gold, and nickel mining. The assessments are based on all significant mineral deposits discovered in Manitoba during the 43-year period 1946-88. Money values are expressed in constant 1990 Canadian dollars.

Assessment of the economic potential of mineral exploration and mine development is made by placing the Manitoba experience in the context of present-day economic and technological conditions. In other words, if we were to begin today to look for the deposits which were in fact discovered during the selected historical period, how long would it take and how much would it cost to find and delineate them? Which of these discoveries would justify development? What revenues and costs would be associated with development and production of the economic deposits? How does the economics of mineral exploration compare with the economics of mine development? In this way, we are endeavouring to use historical experience to provide the Manitoba government with policy and planning guidelines for the future.

Appraisals are initially made on a potential-value, before-tax basis, including all direct costs and revenues associated with mineral exploration and mine development. Then, mining taxation policies in Manitoba are overlaid on the potential value in order to evaluate what these assessments mean in terms of after-tax incentive to the mining company contemplating investment in exploration and development. At the same time, several associated taxation criteria are measured from a government policy viewpoint. Manitoba's competitive tax position in Canada is examined, and the effects of several mining taxation options investigated. Finally, the implications of the March 1992 provincial budget proposals are evaluated. The after-tax analysis illustrates how the study database and evaluation procedure can be applied to analyze mineral policy issues.

Selected study findings are highlighted in graphical form in the text. A more comprehensive set of evaluation results is presented in tabular form in the Appendices. This documentation provides scope for further analysis.

This study was initially prepared by CRS under contract for the Manitoba Department of Energy and Mines. The main report on this work was submitted in November 1990. A supplementary study, "Examination of Manitoba Mining Taxation Options," was completed in February, 1991. Since that time, revisions to the Manitoba database have been made as part of our Canada-wide examination of the economic performance of mineral exploration. A new updated set of results is presented and analyzed in this technical paper.

Organization of the Study

An overview of the study, its main findings, and policy implications are first presented in the Executive Summary.

Chapter 2 describes the evaluation procedure developed to assess the economic potential of mineral exploration and mine development. The methodology provides terms of reference for assembling the study database, and for evaluating and explaining results.

The database for base metal, gold, and nickel exploration and development activities in Manitoba is presented in Chapter 3. The information assembled includes the estimation of total exploration expenditures, a listing of possible economic discoveries for evaluation, projections of long-term metal prices, the estimation of ore reserves and costs for individual deposits based on historical experience, and the development of generalized revenue relationships and deposit-costing relationships.

Chapter 4 appraises the economic potential of mineral exploration and mine development in Manitoba, including the analysis of time trends. The sensitivity of economic criteria to possible variations in metal prices, the cost of capital, and the annual exploration budget is then examined in Chapter 5. The impact of the Thompson Main discovery on overall study results is also addressed.

Chapter 6 considers the impact of taxation on the economic potential assessed in Chapters 4 and 5. Manitoba's competitive tax position in Canada is then examined in Chapter 7. Chapter 8 analyzes the effects of possible changes in Manitoba's mining taxation policy on the province's competitive standing. Finally, Chapter 9 examines the ramifications of changes to Manitoba's mining taxation as proposed in the March 1992 budget.

Several matters summarized in the text are described in greater detail in the Appendices. The inflation multiplier series applied in the study is shown in Appendix I. Appendix II describes the method adopted for estimating exploration expenditures and gives more detailed breakdowns. The possible economic discoveries included in the evaluation are listed and classified in Appendix III. Other discoveries considered but excluded from the evaluation are itemized in Appendix IV. Appendix V describes the general revenue and cost relationships utilized. The Manitoba and federal taxation systems applied in Chapters 7-9 are described in Appendix VII. A comprehensive set of study results is tabled as follows:

- before-tax evaluation results in Appendix VI;
- after-tax evaluation results for the current Manitoba taxation system in Appendix VIII;

- after-tax evaluation results for Manitoba's competitive position in Canada in Appendix IX;
- after-tax evaluation results for Manitoba mining taxation options in Appendix X;
- after-tax evaluation results for the Manitoba taxation systems proposed in March 1992 in Appendix XI.

2. Appraising the Economic Potential of Mining: The Methodology

The purpose of this chapter is to describe the evaluation procedure used to assess the potential value of mining in Manitoba. The concept of the *mineral supply process* which follows provides a framework for appraising the economic potential of mining for this purpose.

The Mineral Supply Process

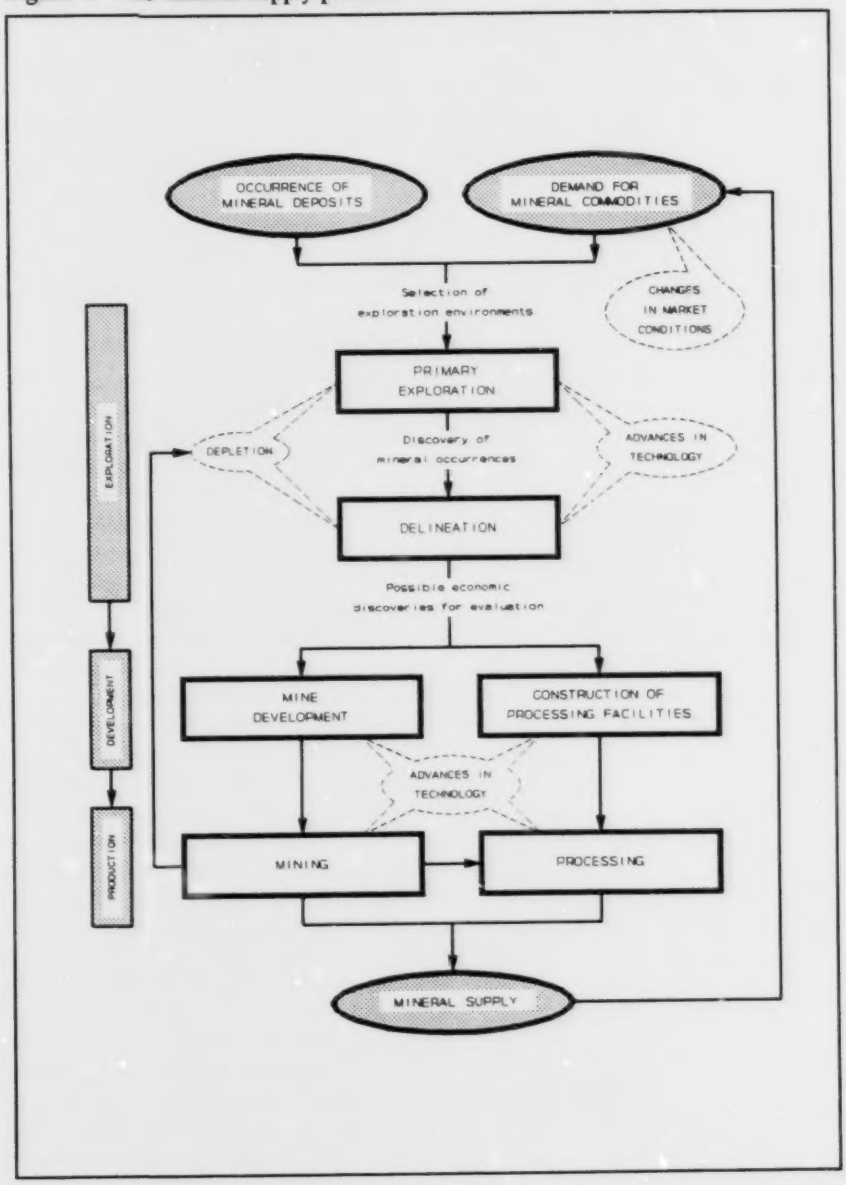
The mineral supply process consists of a series of activities by which minerals are converted from unknown geologic resources to marketable commodities. As portrayed in Figure 1 and described below, the major phases of activity in the process are exploration, development, and production. The basic stimuli of this process are the physical occurrence of mineral deposits in nature and the demand for mineral commodities in the economy. Positive responses from both exploration geologists and market researchers to particular geologic and market factors combine to guide the selection of environments for exploration.

Mineral exploration, the first phase of mineral supply, is a sequential, information-gathering process consisting of two stages: primary exploration and delineation. During the primary exploration stage, potentially favourable areas of land are selected within an environment of interest and then are subjected to a series of geological, geophysical, and geochemical tests. Successful primary exploration results in the discovery of one or more mineral occurrences, although at this stage the ultimate size and value of any occurrence are unknown.

The mineral occurrences found provide justification for delineation, the second stage of exploration, during which information is provided for estimating the size, grade, and physical characteristics of the discovery that are relevant to mineral or metal recovery. The objective of delineation is the identification of possible economic discoveries for evaluation. When the delineation stage has yielded enough information on a particular deposit, a decision is made about developing the deposit to production. If the characteristics of the delineated deposit warrant mine development, the mineral exploration phase is completed with what is perceived to be an economic mineral deposit as its end result.

Development, the second phase of the mineral supply process, establishes productive mining and mineral processing capacity. Since processing is required to upgrade the mine product to a metal concentrate or impure bullion that can be transported and sold, the construction of processing facilities is carried out in conjunction with mine development. A mill may be installed at the minesite, or a common processing facility may be used to treat ores from a number of mines in a region.

Figure 1. The mineral supply process



When a mine has been developed and related processing facilities have been constructed, the third phase – production – commences. The mining stage of production may include stripping waste for open pits, preparing stopes (underground excavations for mining), developing ore reserves, drilling, blasting, transporting materials to the processing facilities, filling mined-out stopes, and associated technical and planning services.

For base metal and nickel operations, the processing stage of production usually includes crushing, grinding, flotation, drying, disposal of tailings, and the loading of concentrate products for shipment. Through processing, the ore produced from a base metal mine, which might contain 2 percent copper and 5 percent zinc, may be upgraded to produce a 25 percent copper concentrate and a 55 percent zinc concentrate, with the loss of 10 percent of the copper content and 20 percent of the zinc content in the tailings. For gold ores, processing typically comprises crushing, grinding, cyanidation, carbon-in-pulp adsorption, filtering, tailings disposal, and smelting. For example, a 6.5 gram per tonne gold ore may be treated to obtain a 98 percent gold bullion, with the loss of 6 percent of the gold content in the waste product.

The end result of the mineral supply process in the context of this study is the production of concentrate or bullion at the minesite to satisfy market demand. Market-demand considerations include product transportation and smelting and refining activities as well as the sale of the metal.

Dynamics of the Process

The mineral supply process, as depicted in Figure 1, is dynamic in several respects. First, the market demand for mineral commodities changes with time. The factors that account for changing demand include variations in the requirements of end users, changes in the properties and relative costs of substitute materials, development of new product markets, and modifications in transportation, smelting, and refining conditions.

Second, the physical exhaustion of mineral deposits, or depletion, is inherent in their exploitation. Thus, continual exploration is required just to sustain existing levels of mineral production. Furthermore, exploration, guided by geologic concepts and skills, is a systematic process in the long term, tending to detect first those deposits that are largest, of highest grade, closest to the surface, or closest to market. Consequently, such deposits should, on average, be discovered, developed, and exhausted first, and deposits that are of lower grade, smaller, or harder to find come later. Thus, depletion causes the cost of mineral supply to rise over time.

However, a third, offsetting dynamic force – advances in technology – is also at work. Such advances may include lower-cost and more extensive exploration techniques, and improved mining and mineral-processing methods. This means, for example, that the best deposits are not necessarily found first. Advances in technology act to reduce the cost of mineral supply.

Finally, organizational factors affecting the efficiency of the supply process are also changing with time; for example, with particular reference to exploration: the size, structure, and motivation of exploration groups; the relationship between the exploration group and corporate executives and directors; the

organizational make-up of the exploration industry; and the structure of government incentives.

The effects of these market, depletion, technological, and organizational forces are reflected in time trends in the economics of mineral supply.

Economic Potential of Mining

The potential of mining for wealth creation is defined here as the difference between the revenue realized from mineral production and the costs required to realize those revenues, including an allowance for the cost of capital.[1] Since the cost of capital is deducted, this potential value represents the increase in real wealth to Canadian and Manitoba society which results from investing in exploration rather than in some other economic activity. Thus, the economic potential reflects both the quality of mineral resource endowment and the viability of the mining sector. It also measures the productive capability of mineral resources and represents what is available for sharing between industry and government prior to taxation and other public policy considerations.

[1] The cost of capital is a real cost which affects the wealth created by the mineral supply process.

The economic potential of mining can be conveniently portrayed by the time distribution of average cash flows associated with the discovery of an economic deposit. The long-term attractiveness of mining is evaluated from the start of the exploration. The medium-term view from the start of development measures the return from mining exclusive of the exploration-phase estimates.

Mineral Exploration Economics

As shown in Figure 1, mineral exploration occupies a strategic upfront position in the supply process. At the beginning, all discovery, development, and production activities represent controllable choices. It is the only time a mining company is not committed to particular programs, projects, or mines. In other words, at the start of exploration there are no sunk costs. Thus, there is the widest possible scope for focusing investment to encourage success. If these strategic choices are made judiciously, exploration will be characterized by a rich cost-risk-reward relationship.

The way in which mineral exploration is conducted is determined by its high-risk nature. Thus, exploration comprises a large number of sequential information-gathering steps. Decisions are made at the end of each step as to whether or not to continue. Under conditions of high risk, it is important to limit the cost of the search process in this way by selecting and concentrating on only those few situations which are perceived to have economic potential. Thus, a phased approach to exploration is essential.

Investment in mineral exploration is not supportable as an end in itself. The economics of exploration are determined by the costs, risks, and returns of the three-phase mineral supply process earlier described.

Economic mineral deposits are central to the mineral supply process. Consequently, the economics of exploration can be measured by the relationship between the exploration expenditures required to find and delineate an economic deposit, and the net return associated with its subsequent development and production.

In this study, mineral exploration economics is assessed both on a before-tax or potential-value basis and on an after-tax basis. All direct costs and revenues associated with the exploration, development, and production phases of mineral supply are included.

The cost, risk, and return characteristics of mineral exploration are applied to measure the economic attractiveness of investment. Exploration investment criteria may be conveniently subdivided into long-term and short-term considerations. The basic attractiveness of exploration is evaluated using various measures of expected value. The short-term problems associated with realizing expectations are assessed by risk criteria.

Expected Value Criteria

Expected value measures the average value that exploration yields in the long term, when the successes and failures associated with a very large (theoretically infinite) number of discoveries are considered. The expected value of exploration is derived from the time distribution of average cash flows for the discovery of an economic mineral deposit. This distribution is initially evaluated on a potential-value basis as portrayed in hypothetical terms in Figure 2. Then, to provide measures of investment incentive from the mining company's viewpoint and government revenues, the potential value assessment is converted to an after-tax basis as depicted in Figure 3. It is on an after-tax basis that the mining company decides whether it is worthwhile to invest in exploration. Because of time-value considerations, the average cash flow characteristics must be brought to a common point in time or spread evenly over a common period of time to make a valid assessment. The following two measures of expected value are used in the present study.

1. Expected Value per Economic Discovery

   An exploration expenditure E is required on average for the discovery and delineation of an economic deposit, yielding an average return R. Thus:

   $$EV = R - E$$

   where EV = expected value per economic discovery;

   R = average net return from development and production associated with the discovery of an economic mineral deposit;

   E = average exploration cost required to find and delineate an economic deposit.

   To make a valid comparison, R and E are expressed as discounted values at the start of the exploration phase, using a cost-of-capital estimate for investment funds as the discount rate.

   The higher the EV assessment, the more attractive exploration is perceived to be in the long term. Usually, an expected value greater than zero is regarded as a necessary condition for investment. A negative EV

Figure 2. Potential value of mineral exploration: time distribution of average cash flows for an economic deposit

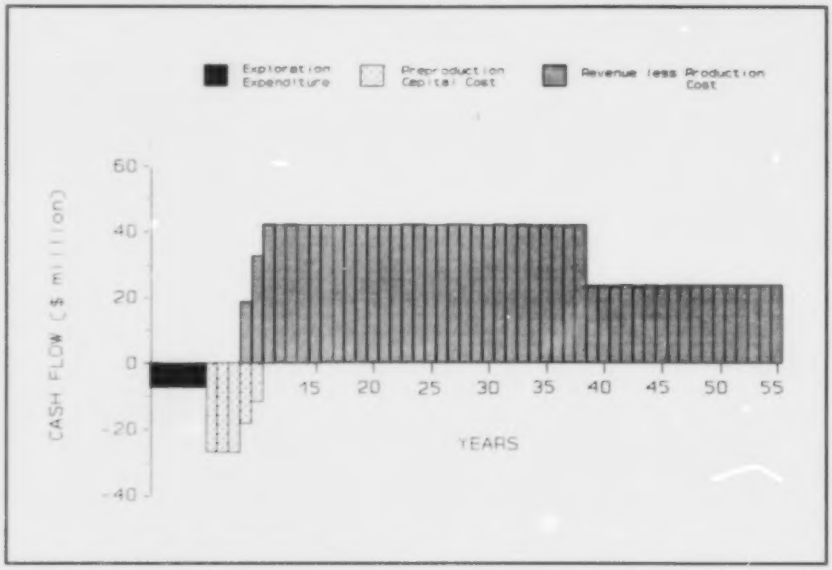
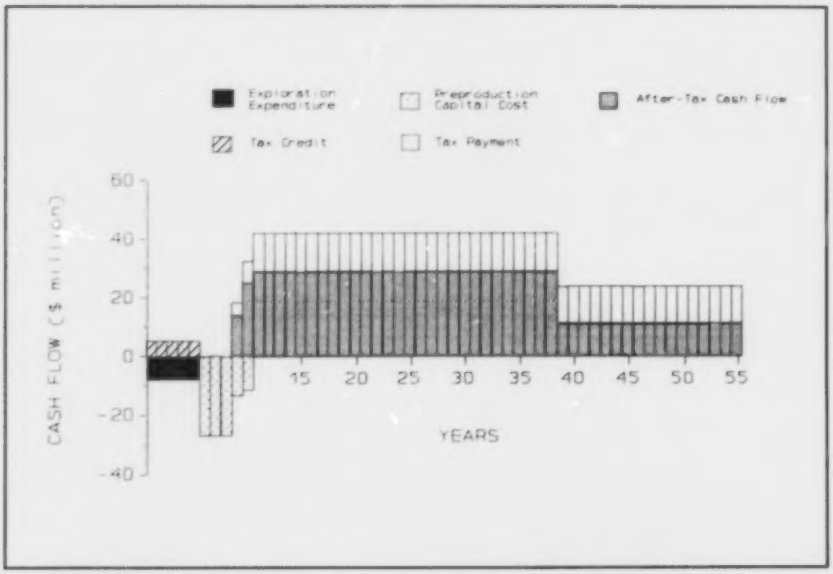


Figure 3. After-tax value of mineral exploration: time distribution of average cash flows for an economic discovery



signifies that exploration is an unacceptable investment in the long term, with more money going *into the ground* in discounted terms than coming out.

The expected value per economic discovery is analogous to the criterion of net present value generally used in evaluation practice. As such, this measure reflects the intrinsic economic value of mineral exploration. Thus, *EV* comprises both size and profitability components.

2. Expected Rate of Return

The expected discounted cash flow rate of return on investment may also be evaluated on the basis of the time distribution of average cash flows for an economic deposit depicted in Figures 2 and 3. By definition, rate of return is the discount rate that equates the present value of the positive cash flows with the present value of the investment. In economic terms, rate of return is the average annual percentage return that exploration is estimated to yield over the life of the mineral supply cycle. Using this method, the minimum acceptable condition for exploration investment is an expected rate of return equal to the cost of capital.

Expected values are assessed in this study on the basis of overall exploration activity and reflect the average performance of all organizations that have undertaken exploration in Manitoba. Obviously, there are benefits to be gained from the application of superior skills and selectivity in exploration. In exploration environments characterized by unacceptable overall expected values, the selection of opportunities of above-average merit is a necessary condition for long-term exploration success. This can only result from the application of superior exploration skills and organizational efficiency, developed within a mining company over time through persistent exposure to particular environments of interest.

Risk Considerations

The four types of risk outlined below are associated with the realization of expected values in mineral exploration.

- *Market risk*, reflecting the sensitivity of exploration economics to the high level of uncertainty associated with forecasts of short-term fluctuations and long-term trends in mineral commodity prices, including exchange rate uncertainty.
- *Project risk*, caused by the uncertainty associated with estimating ore reserves, recovery and dilution factors, capital expenditures, and operating costs for specific economic deposits.
- *Geologic risk*, related to the uncertainty of the return, given an economic discovery, which arises because of the variability in size, grade, and other geologic parameters among economic deposits.

4. *Discovery risk*, the low probability – typically a 1 to 2 percent chance – of an economic mineral deposit, given the discovery of a mineral occurrence.[2] The implications of discovery risk for exploration planning are of particular importance.

[2] The discovery of a mineral occurrence, as portrayed in Figure 1, is the successful outcome of primary exploration or, in other words, a technical or geologic success. More specifically, the discovery of a mineral occurrence can be defined as indications of mineralization of potentially economic grades across mineable widths obtained by drilling. Adopting this definition, empirical studies of mineral exploration in Canada and Australia show that there is typically a .01 to .02 probability of discovering an economic deposit each time a mineral occurrence is found.

These risks, individually and collectively, present challenges to the long-term profit, survival, and growth of organizations active in mineral exploration. Inevitably, actual results are very much different than those indicated on the basis of expected values. To be realistic, an understanding of these risks must be incorporated in exploration planning.

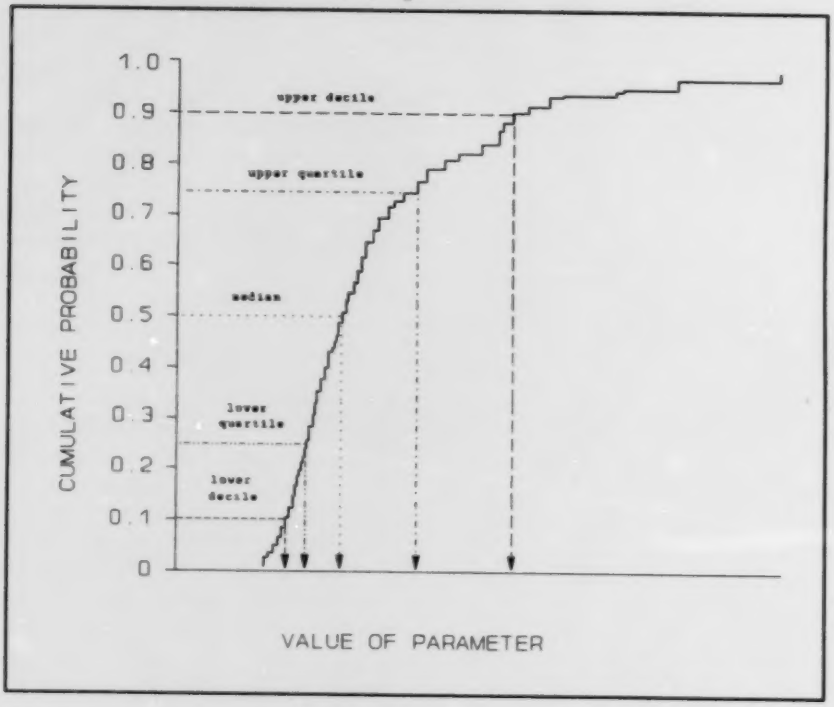
The *market risk* arises from uncertainties in the materials market for mineral commodities. The economics of mineral supply is sensitive to anticipated prices. Flexibility is required to contend with unexpected changes in market conditions. Thus, the assessment made of mineral exploration economics in Manitoba in the present study considers a wide range of possible long-term metal prices.

The *project risk* associated with the estimation of ore reserves, mining and processing costs for a particular mineral deposit is critical when an investment decision is being taken concerning mine development. However, generalizing across many deposit situations to appraise the economics of mineral exploration for broad regions of interest, as we are doing here, makes the individual project risks less germane.

The *geologic risk* may be measured by cumulative probability distributions of return parameters such as total revenue, rate of return, and net present value for all economic discoveries. With reference to Figure 4, cumulative probability distributions are constructed in the following manner. For each return parameter, individual deposit values are ordered from the lowest to the highest. These values are then plotted against cumulative probability, the fraction of the total number of economic deposits which have values less than or equal to each value. When the highest value is reached, the cumulative probability equals unity. Key statistics can then be derived as shown in Figure 4 to represent the overall distribution. For example, a cumulative probability of 0.10 specifies the lower-decile value; i.e. 10 percent of the economic deposits have values less than or equal to the lower decile and 90 percent have higher values. The median (or middle) deposit value is designated by a 0.50 cumulative probability. The mean deposit value is the average of all deposit values. The distribution of returns around the mean value is the economic reflection of the geologic variability which exists among economic deposits.

Because the *discovery risk* is so high, the application of limited exploration funds does not ensure the realization of expected values. Thus, exploration resources are often expended without success. The organizational risk associated with exploration success can be quantified by applying the classical problem of the gambler's ruin. The practical implication of discovery risk for a mining company is that there is a large difference between the average exploration cost required to find and delineate an economic deposit and the exploration funds required to ensure success. For example, the exploration funds required to be 90 percent sure of discovering at least one economic deposit are 2.3 times the average exploration cost associated with an economic discovery.

Figure 4. Cumulative probability distribution and key statistics of a return parameter for economic deposits



Mine Development Economics

Mine development represents the medium-term view of the attractiveness of the mineral supply process. At this point, the exploration-phase investment is a sunk cost. The discovery and geologic risks both have been resolved; a particular economic deposit, found and delineated, now awaits development.

The development of an economic deposit is the end result of successful exploration. Because exploration time and cost have been expended in resolving risks to arrive at this favourable outcome, the economics of mine development, as we will see, are typically much more attractive than the economics of mineral exploration. Corresponding to the long-term view from the start of exploration, development economics are appraised using both expected value measures and risk criteria.

Expected Value Criteria

The expected value of mine development measures the average revenues and costs of the development and production phases of the mineral supply process. To obtain a representative general picture of mine development economics, cash flow estimates can be averaged across all economic deposits discovered.

The time distribution of average cash flows for an economic mineral deposit is illustrated in Figure 5 on a potential-value basis and after tax in Figure 6. These hypothetical cash flow distributions, it should be noted, are identical to the development and production phase values depicted in Figures 2 and 3.

Each time a mine development decision is taken, however, it is the cash flow profile of the particular deposit being considered that is relevant, not the average representations shown in Figures 5 and 6. The variability in cash flow characteristics among economic deposits is therefore an important factor to examine when considering the economics of mine development.

In a way comparable to that outlined for mineral exploration, discounted cash flow methods are applied to summarize the cash flow estimates in terms of expected value criteria. Once again, two measures of expected value are selected for use in the study.

1. Expected Net Present Value

   The expected net present value converts the anticipated time distribution of cash flows for a new project into an equivalent dollar value at the start of development. To do this, each cash flow is discounted to this point in time using the cost of capital rate. The present value components are then summed to yield the expected net present value. Thus, net present value is the difference between the discounted positive cash flows from production and the discounted development phase investment.[3] Using this criterion, the minimum acceptable condition for investment in mine development is an expected net present value equal to zero.

2. Expected Rate of Return

   The expected rate of return for mine development is the discount rate which equates the present value of the positive cash flows from production with the present value of the development-phase investment. In other words, the expected rate of return is the discount rate which gives a zero net present value. Using this criterion, the minimum acceptable condition for investment in mine development is an expected rate of return equal to the cost of capital.

[3] With reference to the exploration criteria previously outlined, the expected net present value is directly related to R, the only difference being that R is time-adjusted to the start of exploration rather than to the start of development.

Risk Considerations

The *discovery risk* and the *geologic risk* previously outlined are resolved in the exploration phase prior to appraising the economics of mine development. A particular economic deposit is now available for mine development, sampled by a successful exploration program from the total population of undiscovered economic deposits. The cash flow profile and the economic criteria associated with the mine development opportunity are determined in part by the geologic characteristics which have been delineated.

The *market risk* associated with mine development is similar to that associated with mineral exploration. Because potential mine output is closer at hand, more reliable price projections may be possible but, typically, a high level of market uncertainty will remain until it is resolved year by year in the course of production. The *project risk* associated with the estimation of ore reserves, capital expenditures, and operating costs is also of critical importance to evaluation and decision-making at the development decision point. These

Figure 5. Potential value of mine development: time distribution of average cash flows for an economic deposit

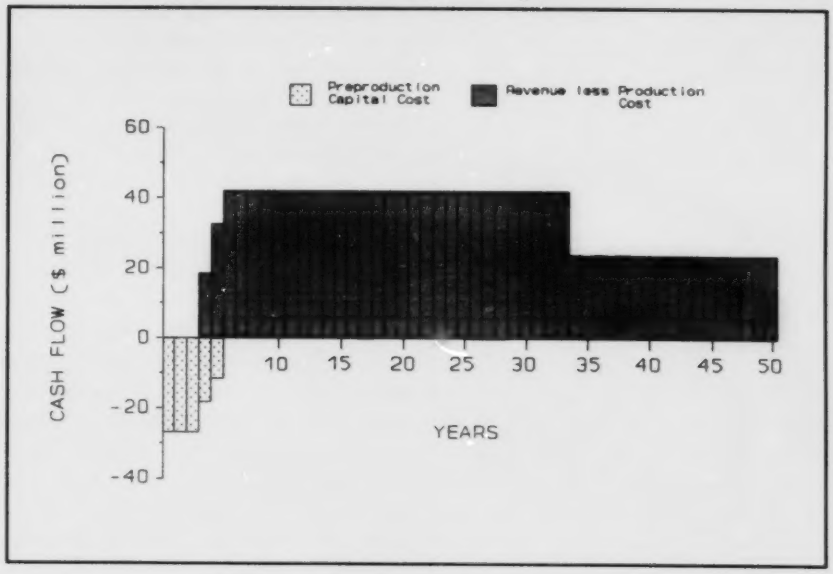
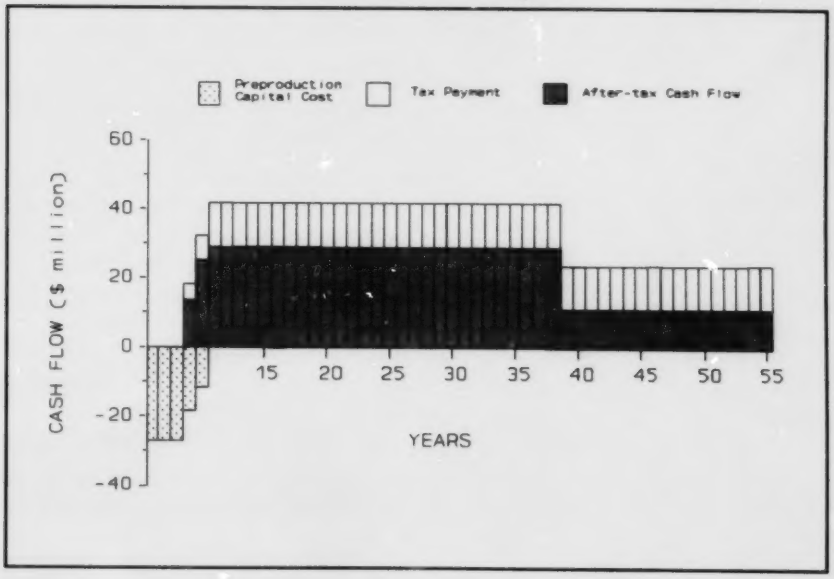


Figure 6. After-tax value of mine development: time distribution of average cash flows for an economic deposit



market and project risks can be evaluated using sensitivity analysis and, more comprehensively, by applying probabilistic risk analysis methods.

In the present study, market risk is examined using sensitivity analysis. No attempt is made to measure project risk. The broad comparative nature of the study, assessing the economics of many potential mine development opportunities, makes this impractical. In any case, we are not faced here with taking a capital-intensive mine-development decision for a particular deposit. Rather, we are endeavouring to create a more general awareness of mine development economics for exploration planning purposes.

Evaluation Procedure

The economic potential of mining is determined by the costs and revenues of the exploration, development, and production phases of the mineral supply process. The focal point of this process is economic mineral deposits. Consequently, potential value measures are derived from estimates of the exploration expenditures, development costs, and production revenues and costs associated with an economic deposit.

In the evaluation procedure described here and applied in the study, the starting point is to assemble as much information as possible on the actual historical experience. Then, so that results are as relevant as possible for current policy and planning purposes, this experience is estimated and appraised in terms of present-day economic and technological outlook conditions.

The approach adopted is predicated, therefore, on the basic premise that the past can provide useful guidelines in planning for the future. Two main assumptions are incorporated:

- the cost of making a future discovery will be comparable to the cost in the past;
- deposits yet to be found resemble, in economic terms, those that have been discovered to date.

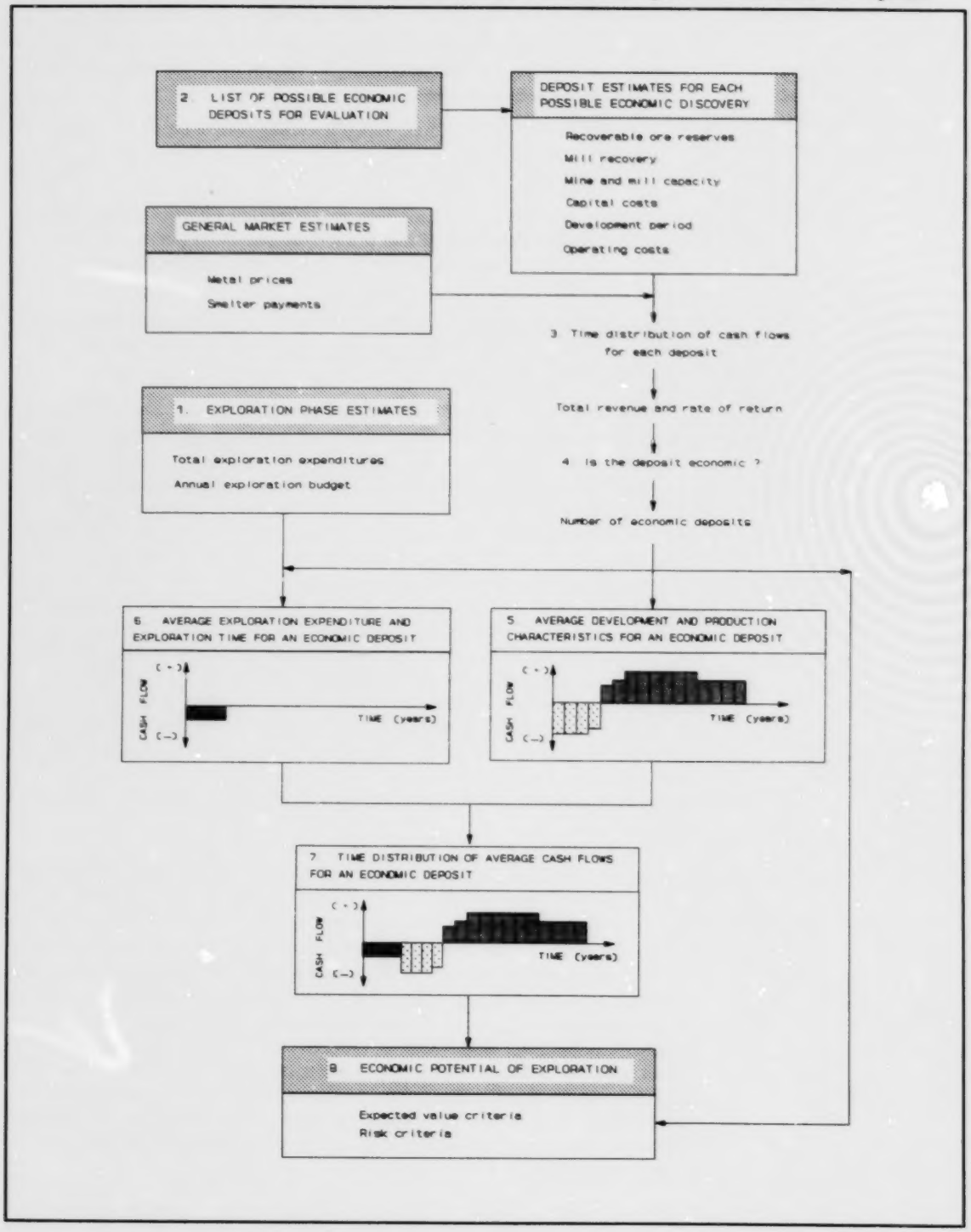
However, since the mineral supply process, as previously described, is dynamic, we should endeavour to discern time trends within the overall appraisals.

The database for assessing the potential value of an economic deposit comprises the documentation of actual exploration, development, and production experience over a relevant historical timeframe – the 1946-88 period is selected in our appraisal of exploration and development potential in Manitoba introduced in Chapter 3. As already mentioned, for present-day planning purposes, this information is then evaluated in the context of current outlook conditions.

In essence, the methodology (diagrammed in Figure 7) follows these steps.

1. Total exploration expenditures are estimated for the historical time period of interest and an assumption is made to determine the exploration period.
2. Possible economic deposits discovered as a result of these expenditures are classified by discovery date and listed for evaluation.
3. The cash flow characteristics of the development and production phases for each of these possible economic discoveries are evaluated on the basis of current-outlook market conditions and deposit-specific estimates.

Figure 7. Procedure for evaluating the economic potential of mineral exploration and mine development


2 LIST OF POSSIBLE ECONOMIC DEPOSITS FOR EVALUATION
DEPOSIT ESTIMATES FOR EACH POSSIBLE ECONOMIC DISCOVERY
Recoverable ore reserves
Mill recovery
Mine and mill capacity
Capital costs
Development period
Operating costs
GENERAL MARKET ESTIMATES
Metal prices
Smelter payments
3 Time distribution of cash flows for each deposit
Total revenue and rate of return
4 Is the deposit economic ?
Number of economic deposits
1. EXPLORATION PHASE ESTIMATES
Total exploration expenditures
Annual exploration budget
6 AVERAGE EXPLORATION EXPENDITURE AND EXPLORATION TIME FOR AN ECONOMIC DEPOSIT
5 AVERAGE DEVELOPMENT AND PRODUCTION CHARACTERISTICS FOR AN ECONOMIC DEPOSIT
CASH FLOW
TIME (years)
7 TIME DISTRIBUTION OF AVERAGE CASH FLOWS FOR AN ECONOMIC DEPOSIT
8 ECONOMIC POTENTIAL OF EXPLORATION
Expected value criteria
Risk criteria

4. Discoveries that, on evaluation, satisfy minimum conditions of size and profitability are designated as economic deposits.
5. Cash flow characteristics of the development and production phases for all economic deposits are analyzed to depict variability in the economics of mine development and then are averaged.
6. Total exploration expenditures, which normally cannot be directly associated with the economic discoveries, are prorated across all economic deposits evaluated.
7. Estimates for the exploration phase are integrated with the average characteristics for the development and production phases to portray the time distribution of average cash flows for an economic deposit from the start of exploration to the end of production.
8. The expected value criteria and risk measures earlier described are derived from the assessment. These indicators reflect the economic potential of mineral exploration.

More specifically, the development and production phase characteristics for each of the possible economic discoveries (step 2 above) are evaluated (step 3), as shown in Figure 7, by combining general market estimates of metal prices and smelter payments with estimates of the following individual deposit parameters: recoverable ore reserves; mill recovery factors; a stripping ratio for open pits; mine and mill capacities; capital costs, including the working capital requirement; the length of the preproduction development period; and operating costs. These estimates, based on the actual historical record, attempt to portray how each deposit would look today if it were awaiting development. A number of measures of economic worth are derived from the resulting cash flow distributions, including the total sales revenue generated and the rate of return. Those discoveries that satisfy minimum conditions for total revenue (size) and rate of return (profitability) are deemed to be economic (step 4). The return characteristics of the economic deposits are analyzed to portray the economics of mine development in Manitoba. The cash flow estimates for all economic deposits are then averaged (step 5), resulting in a time distribution of average cash flows for the development and production phases of the mineral supply process.

With respect to appraisal of the exploration phase (step 6), the total exploration expenditure estimate (step 1) is divided by the number of economic deposits assessed (step 4) to determine the average exploration expenditure required to find and delineate an economic deposit. The assumption of an annual exploration budget rate is used to ascertain the time distribution of this average exploration expenditure. These estimates for the exploration phase are then integrated with the appraisals for the development and production phases.

As portrayed in Figure 7, the end result of this evaluation process is an assessment of the time distribution of average cash flows for an economic deposit over the entire mineral supply process (step 7). The expected value and risk measures thereby determined to depict the before-tax, potential-value characteristics of mineral exploration in Manitoba (step 8) have been outlined earlier. As part of the appraisal, the sensitivity of results to key study assumptions is examined.

Summing Up

Appraisals of the economics of mineral exploration are derived from estimates of the exploration expenditures, development costs, and production revenues and costs associated with an economic deposit. The evaluation procedure adopted mixes historical discoveries and developments with future costs and prices to arrive at a *present day* appraisal of these deposits. This provides an objective basis for assessing the economic potential of mineral exploration and development in Manitoba and, then, examining the effects of mining taxation policies.

3. Mineral Exploration and Development in Manitoba: The Study Database

Study Specifications

The study concerns base metal, gold, and nickel mining in Manitoba. The assessments of mineral exploration and development potential are based on the 43-year period 1946-88. This time period is divided into two intervals – 1946-69 and 1970-88 – to examine time trends in exploration and development characteristics.

Unless otherwise specified, money values are expressed in constant 1990 Canadian dollars. Discount rates and costs of capital are therefore expressed as real rather than nominal rates. Inflation is taken into account to correctly assess tax allowances and payments.

Trends in historical current-dollar statistics that are purely inflationary are removed by applying the Gross Domestic Product (GDP) Implicit Price Index. This aggregate price index provides a good approximation of the economy-wide rate of inflation. The GDP Implicit Price Index and the inflation multiplier series derived from it to convert historical data to 1990-dollar equivalents are shown in Appendix I.

One aspect of our evaluation is to determine which of the mineral deposits discovered in the past would be economic under today's conditions. An economic deposit is defined as a discovery that realizes a total revenue of at least $20 million and a rate of return of at least 8 percent. The $20-million minimum size criterion is designed to keep the database to manageable proportions while ensuring that any deposit of significance is included in the study. The 8 percent rate-of-return investment margin has been selected as a best estimate of the weighted average cost of capital for mineral investment funds.[4] The effects of profitability thresholds of 5 percent, 12 percent, and 15 percent on exploration and development potential are also examined.

Total Exploration Expenditures

Estimates of total exploration expenditures are required to assess the exploration phase of the mineral supply process. The aim is to include all costs associated with searching for and delineating the possible economic discoveries of interest. Unsuccessful exploration expenditures are, of course, the main component of these costs. Total exploration expenditures are difficult to estimate, mainly because government statistics are too aggregated to be directly applicable.

The approach used to estimate mineral exploration expenditures for study purposes is described in Appendix II. Several sources have been tapped in deriving the final study series, including federal and Manitoba government agencies, and exploration personnel in mining companies.

[4] The weighted average cost of capital in constant-money terms comprises the costs of individual sources of funds which may be simply grouped into two types – debt and equity. The cost of debt capital is an explicit interest cost in current money terms. The cost of equity funds is an implicit opportunity cost which can be estimated empirically.

Considering inflation and taxation effects, debt capital is a low-cost source of funds, with constant-money after-tax costs typically ranging from 1 to 3 percent. The cost of equity funds normally varies from 6 to 15 percent. The financial structure of a company – basically, how much debt and how much equity it utilizes – is applied to cost estimates for the individual sources to assess the weighted average cost of capital.

Empirical assessments of the weighted average cost of capital for multinational mining companies active in Australia and Canada generally fall within the range of 6 to 13 percent. The 8 percent cost of capital assumed in the study base case, as well as the variants examined, should be viewed within this framework.

Here, a deposit is considered economic if the "expected" rate of return evaluated is greater than the cost of capital. The analysis ignores project risk. Realistically, the minimum expected return has to be set several points higher than the cost of capital to provide reasonable confidence that projects accepted for development will in fact be economic.

Most deposits in the study database already have been mined. Therefore, much more is known about their ore reserve and cost characteristics than was actually known at the time they were developed. Thus, risk is relatively low. Nevertheless, our approach does tend to give the benefit of the doubt to marginal opportunities.

As in earlier CRS studies, the Dominion Bureau of Statistics series on the cost of prospecting have been used extensively for the 1946-63 period. For the remainder of the study period, Statistics Canada data for both on-property and off-property exploration expenditures are the primary source. Only off-property expenditures were included in earlier CRS studies. There are several reasons for now including on-property expenditures:

- a substantial amount of primary exploration for new deposits is carried out on existing mine leases;
- our evaluation of mine development potential is based on the most complete ore reserve estimates available;
- on-property exploration is a valid activity to be included in total exploration for evaluation purposes.

The resulting series of exploration expenditures are presented in Appendix II and Figure 8. The time distribution is characterized by pronounced and remarkably regular cycles around an average exploration expenditure of $25 million per year. Peaks occur in 1947, 1958, 1970, 1980, and then again in the mid-1980s.

Table 1 summarizes these expenditures by commodity grouping and time interval. Exploration expenditures in Manitoba for the study period total almost $1.1 billion, split between base metals (37 percent), gold (14 percent), and nickel (49 percent). The level of exploration activity is quite well balanced between the two study intervals.

Figure 8. Total exploration expenditures

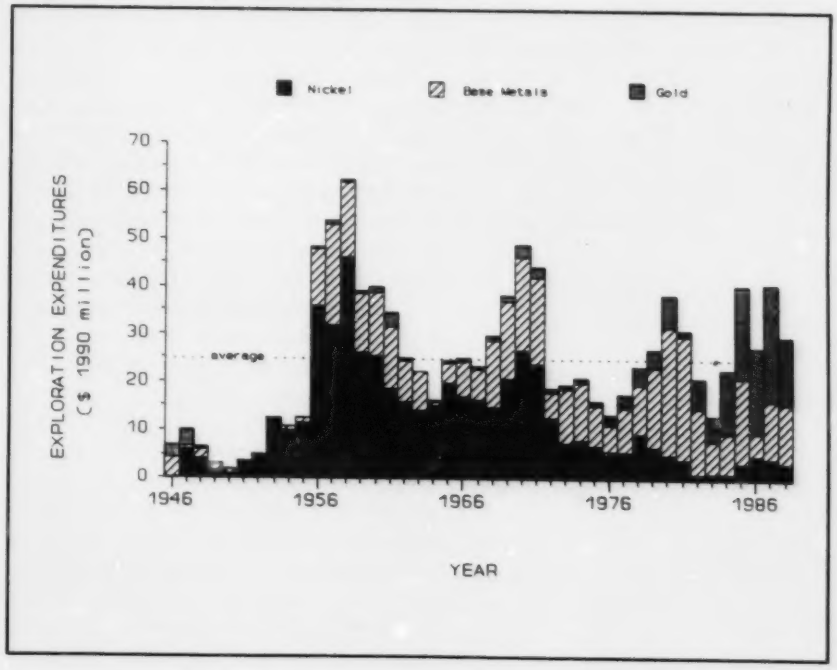


Table 1. Total exploration expenditures ($1990, millions)

	Time Interval		
Commodity Grouping	1946-69	1970-88	1946-88
Base metals	238	159	397
Gold	129	21	150
Nickel	144	373	517
Total	511	553	1,064

Determining the Exploration Period

In order to determine the time distribution of the average exploration expenditure per economic discovery, an assumption is required.

The approach used is to assume a most efficient annual rate of expenditure for an exploration organization. This annual exploration budget rate is divided into the average exploration expenditure per economic discovery to determine the average exploration time which would be needed to discover and delineate an economic deposit.

A $6-million annual exploration budget has been selected as the most efficient level for an exploration organization and is incorporated in the study base case. This budget rate is considered large enough to afford the best possible exploration skills and technologies, and small enough to encourage a high degree of motivation and organizational efficiency. The effects of exploration budgets of $3 million and $9 million per year are also examined.

A group of five to eight geologists – "hunting band" size – with an annual budget of $3.0 million to $9.0 million appears to be the most efficient and effective, retaining the characteristics of an entrepreneurial organization while avoiding the weaknesses of a bureaucracy. Bailly (1977) analyzed the relationship between exploration expenditures and the number of economic deposits discovered as a function of exploration budget size, considering the case of metallic mineral exploration in Canada during the 1958-73 period. His results, converted in Table 2 to 1990 Canadian dollars, show that a budget range from $1.7 million to $9.2 million is much more efficient than larger or smaller sizes. If the exploration budget is too small, an exploration organization cannot mount a modern, efficient, and competitive program. At the other extreme, companies with larger budgets typically develop organizations where procedures become formalized and bureaucratic styles develop. The inefficiencies of organizations with large budgets are shown clearly in Bailly's results.

A dilemma arises when a mining company wishes to commit large amounts to exploration yet remain efficient. One way to resolve this problem is to divide exploration activity into a number of decentralized, semi-autonomous units that are able to maintain favourable organizational characteristics with competitive budget and staff sizes. These units would be given broad guidelines by a central exploration group, and provided with specialized, high-quality support, as well as the financial backing to sustain exploration activities.

Table 2. Relationship between exploration budget size and exploration success

Annual Exploration Budget	Percentage of Exploration Expenditures	Percentage of Economic Discoveries
> $9.2 million	44	15
$3.6 - $9.2 million	14	35
$1.7 - $3.6 million	13	40
< $1.7 million	29	10

Source: Bailly (1977).

Possible Economic Discoveries for Evaluation

In Manitoba, 56 base metal, gold and nickel deposits discovered during the 1946-88 study period which could possibly satisfy our *economic deposit* definition have been selected for evaluation. These deposits are listed in alphabetical order in Appendix III, classified by commodity grouping and discovery date. A list of 82 other Manitoba deposits considered but not included in the evaluation is given in Appendix IV with reasons for their exclusion.

A discovery is considered to have been made when the deposit that ultimately forms the basis for mine development was first recognized, usually by drilling. Deposits are treated individually if their discovery required essentially independent primary exploration programs. The intention is to include all known deposits of at least 200,000 tonnes that offer medium-term potential for development. Exceptions are occasionally made below this size threshold for deposits of exceptionally high grade.

The time distribution of possible economic discoveries in Manitoba is shown in Figure 9 and summarized in Table 3. Generally, the discovery pattern and rate follow the ups and downs in exploration expenditures shown in Figure 8. Of the 56 significant discoveries, 57 percent are base metal deposits, 13 percent are gold deposits, and 30 percent are nickel deposits. It is interesting that 1984 is the peak year for number of deposits found, and the only year in which possible economic deposits of all three types were discovered.

General Market Estimates

General market estimates are made to evaluate the time distribution of revenues for each of the possible economic discoveries. Since metal price is both the most important and the most uncertain variable in the assessment of cash flows, cash flows are evaluated as a function of price. An expected or mean price outlook is bounded by upper- and lower-limit prices for each mineral commodity.

The prices used in the study are shown in Table 4. These are long-term average price estimates, the period of which is intended to correspond to the time frame of the three-phase mineral supply process being evaluated.

Figure 9. Number of possible economic deposits for evaluation

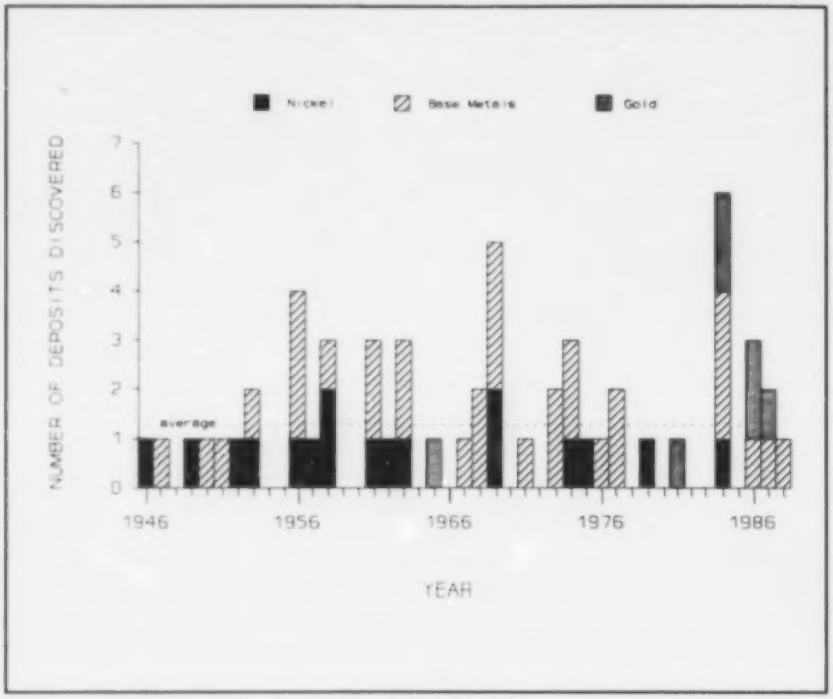


Table 3. Number of possible economic deposits for evaluation

	Time Interval		
Commodity Grouping	1946-69	1970-88	1946-88
Base metals	18	14	32
Gold	1	6	7
Nickel	13	4	17
Total	32	24	56

The assessment of costs and revenues assumes that concentrate or bullion is produced at each possible mine. General net smelter return conditions for copper, lead, zinc, and nickel concentrates are used to convert the forecast metal prices to a revenue estimate for the sale of concentrate at the smelter. Concentrate transportation costs are then deducted to work the smelter payment back to a minesite value. In the case of gold deposits, all-inclusive marketing charges are levied for impure bullion and gold concentrate products. The smelter return conditions, concentrate transportation costs, and gold marketing charges used in the study are outlined in Appendix V.

Table 4. Long-term price variants for mineral commodities (U.S. $ 1990)

Metal	Price Basis	Price Variants		
		Lower-Limit	Expected	Upper-Limit
Primary importance:				
Copper	pound	0.80	1.05	1.25
Gold	ounce	250	400	500
Nickel	pound	2.75	3.50	4.50
Zinc	pound	0.40	0.60	0.70
Secondary importance:				
Cobalt	pound	5.50	7.50	10.00
Lead	pound	0.30	0.35	0.45
Silver	ounce	4.00	6.00	9.00
Exchange rate	US$/C$	0.95	0.80	0.65

Estimates for the Possible Economic Deposits

Historical information first is assembled for each of the possible economic deposits including production, reserve, cost, and recovery data. Also, corporate planning projections, and feasibility study estimates are obtained whenever possible and appropriate. Otherwise, when deposit-specific data are not available, general Canadian mine-costing relationships are utilized, reflecting an order-of-magnitude (±30 percent) level of accuracy.

Deposit-specific projections, assuming current economic and technological conditions, are then derived from this information for each of the 56 possible economic deposits. These estimates provide the basis for evaluating which of the historical discoveries represent worthwhile exploration targets today and what their economic return characteristics would be under these circumstances.

In each case, the following deposit projections are required:

- recoverable ore reserves;
- mine and mill capacities;
- preproduction period;
- preproduction capital expenditures, including the working capital requirement;
- the capital cost of major modifications;
- sustaining capital requirements;
- operating costs;
- mill recovery factors;

- concentrate and bullion grades;
- specifications for concentrate transportation.

The form in which the basic estimates are provided for each deposit is shown in Figure 10. The coding scheme maintains the anonymity of the deposits and facilitates their classification for analysis. Coding specifies the following deposit characteristics:

1	exploration environment
2	province or territory
3	deposit code
4,5,6	geological classifications
7	mining method
8	underground stoping method
9	general surface services
10	mine and mill site preparation
11	host rock conditions for shaft sinking
12	ground conditions for concrete foundations
13	temperature conditions
14	grinding conditions
15,16	ore type for mineral processing
17	conditions for tailings storage

The first sheet of deposit estimates (Figure 10) and the top of the second sheet (to the dotted line) itemize the information which must be specified to evaluate a deposit on the basis of the order-of-magnitude costing relationships. Estimates based on actual deposit data and corporate planning or feasibility study projections are entered below the dotted line on the second sheet.

As noted above, the general deposit costing relationships used in the appraisal when actual data or specific estimates are not available, provide an order-of-magnitude ($\pm$30 percent) level of accuracy. These relationships are outlined in Appendix V.

Where more than one possible economic discovery of the same type exists in a region, the deposits are evaluated assuming the utilization of common processing and infrastructure facilities, irrespective of ownership considerations.[5]

An overall regional capacity is specified, and a core group of deposits is selected to carry the capital load of the common facilities.[6] The common capital expenditures are then allocated to the individual members of the core group based on their relative capacities. Satellite discoveries in a region are charged for incremental infrastructure requirements (e.g. for mine access road and powerline extensions) but, otherwise, are given a free ride with respect to the common capital expenditures.

When one or more of the core deposits is found on evaluation to be uneconomic, the common capital is reallocated among the economic projects. Trial evaluations are repeated until all remaining core deposits are shown to be economic or uneconomic. At appropriate points, the overall regional capacity is down-sized to suit the capability of the smaller number of core deposits remaining.

[5] While inter-company barriers to sharing regional facilities certainly exist, especially in the shorter term, they are ignored here because we wish to assess the intrinsic economic value of the deposits.

[6] For example, consider the case of possible economic base metal deposits in the Snow Lake region. For the base case evaluation, a regional capacity of 1,000,000tonnes per year is assumed. The common capital expenditures are allocated among four core deposits: Chisel Lake, Chisel North, Rod, and Stall.

Figure 10. Deposit estimate form

DEPOSIT INFORMATION FORM -- CANADA

DEPOSIT CODE:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

DISCOVERY DATE:

GEOLOGICAL RESERVES:

1.
2.
3.

MINING METHOD:

RECOVERABLE RESERVES:

1.
2.
3.

PREPRODUCTION STRIPPING (m^3):

Unconsolidated overburden .....
Waste rock .....

AVERAGE STRIPPING RATIO (w:o):

AVERAGE ORE WIDTH (m):

SHAFT DEPTH (m):

MAJOR MODIFICATIONS:

ROADS (km):

FLY-IN PROGRAM (yes/no): DISTANCE (km):

ACCOMMODATIONS (% of employees):

Houses .....
Permanent bunkhouse facilities .....

AMENITIES (% of employees):

Townsite .....
Campsite .....

Figure 10. Deposit estimate form (continued)

REGIONAL MILL ALTERNATIVE:
- Capacity (tonnes per year) .....
- Ore transport distance (km) .....
- Roads required (km) .....

CONCENTRATE TRANSPORTATION:

Commodity	_____	_____	_____	_____
Destination				
Road distance (km)				
Rail distance (km)				
Ocean route				

ACTUAL INFORMATION

ORE CAPACITY (tonnes per year):

MINE RECOVERY (%):

MINE DILUTION (%):

AVERAGE ORE WIDTH (m):

PREPRODUCTION PERIOD (years):

PREPRODUCTION CAPITAL COSTS ($ million or % change):

Mine development	Infrastructure Breakdown
Mine plant and equipment	Roads
Mill facilities	Housing
Infrastructure	Townsite
Working capital	Power
---	---
Total	Total

OPERATING COSTS ($ per tonne of ore or % change):
- Mining
- Milling
- Overheads

Total

METALLURGICAL RECOVERIES (%):

CONCENTRATE GRADES (%):

Table 5 presents average mine development parameters for all deposits in the study database. These statistics may be viewed as providing a representative deposit profile. However, keep in mind that a high degree of variability in the values for individual deposits is being averaged together in each case.[7]

[7] It may be noted in Table 5 that the combination of average statistics does not give the average statistics of the combination. Thus, average recoverable ore reserves times average unit revenue does not equal average total revenue. Similarly, average recoverable ore reserves divided by average annual mill capacity does not give the average productive mine life. These inequalities are caused by the correlations which exist between the variables being combined.

Table 5. Average mine development parameters for the 56 possible economic deposits

	Average Value
Recoverable ore reserves (million tonnes)	8
Annual mine capacity (thousand tonnes)	424
Productive mine life (years)	13
Preproduction capital cost ($ million)	59
Unit production costs ($ per tonne)	58
Unit revenue ($ per tonne)	76
Total revenue ($ million)	735

Notes: tonnes refer to the quantity of ore mined and milled; the unit and total revenue estimates are based on expected metal prices and evaluated at the minesite.

Critique of the Database

The information utilized for this study has been assembled on a continuing basis since 1972. A major update and extension for Manitoba were completed as part of the present study with excellent cooperation from the mining companies concerned. Nevertheless, there are several database limitations.

First, possible economic deposits are classified on the basis of their discovery dates. As there is an uncertain time lag between the start of exploration and the discovery of a deposit, it is possible that exploration expenditures included in the economic assessment for one time interval, may result in discoveries included in the following time interval, or vice versa. Since we are examining one 24-year and one 19-year interval, this discrepancy should not significantly alter time trends. It may be important however, if, as a result, possible economic deposits are excluded from the overall time period. The 43-year period chosen is considered to be of sufficient duration to minimize these spillover effects.

Second, the database for older mines tends to be more complete than that for the more recent discoveries. This is especially important with respect to ore reserve estimates, since development and production typically proceed on the basis of partial delineation results. Our objective has been to include as complete an estimate as possible for the tonnage and grade characteristics of each deposit. There is nevertheless an inevitable tendency to undervalue the appraisals, especially for deposits discovered in the most recent time interval. The possible undervaluation is particularly significant with respect to ore reserve tonnage. This problem can be eased only by periodic updating and improvement of the database.

Third, the order-of-magnitude costing relationships which we utilize were developed more than five years ago. It is uncertain how these functions should be indexed to correctly reflect cost conditions in the early 1990s. The general inflation multiplier series (Appendix I) indicates that an index of 1.21 should be applied to convert 1985 Canadian dollar costs to 1990 Canadian dollar equivalents. However, this index ignores the changes in technology, productivity, and organizational efficiency which have taken place in the Manitoba mining sector during the late 1980s. Because we are uneasy about this indexing assumption, we have endeavoured to minimize the use of the order-of-magnitude relationships. Thus, most all of the Manitoba deposit estimates are based on more specific and up-to-date data sources.

Finally, it can be argued that the use of historical exploration expenditures results in overestimating the exploration costs that would be required under today's conditions. This contention is based on the increasing effectiveness of exploration. Thus, it would presently require lower exploration expenditures to find the deposits which were discovered historically. However, as discussed in Chapter 2, both depletion effects and advances in technology act over time, which may lead to either an increase or a decrease in finding costs, depending on their resultant. In this study, these effects are examined by studying time trends within the overall 43-year study period. Otherwise, it is reasoned that the cost of making a future discovery will be similar to the cost in the past.

These and other shortcomings in the database reflect a compromise between the availability of data and the research limitations imposed by time constraints. While there is room for improvement, it is suggested that the existing Manitoba database is of a high quality, certainly sufficient to support a useful and meaningful appraisal of mining potential in Manitoba, and related tax issues.

Data Processing

The database is processed by computer programs developed for the Centre for Resource Studies by Professor Michel Bilodeau, Department of Mining and Metallurgical Engineering, McGill University. There are three separate procedures which are named MINDEC 1, MINDEC 2 and MINDEC 3.

MINDEC 1 is a program that computes the development and production characteristics of each possible deposit. The MINDEC 2 program then retrieves the cash flow elements and economic characteristics of the economic mineral deposits, computes their averages, lists the unit development and production components of cash flow for an economic deposit, and plots cumulative probability distributions. MINDEC 3 is a program to retrieve the yearly cash flow elements of economic mineral deposits. It then computes the time distribution of average cash flows for an economic deposit and associated economic characteristics with and without the average exploration period cash flows.

Variants for Analysis

Our before-tax appraisal of mineral exploration and development potential in Manitoba, presented in Chapters 3 and 4, comprises the following variants:

- economic potential of mineral exploration;
- economic potential of mine development;
- time trends in economic performance;
- sensitivity of economic potential to key study parameters:
  - metal price variants;
  - annual exploration budget variants;
  - cost of capital variants;
  - effect of an exploration-development time gap;
  - exclusion of the multi-billion dollar discovery.

4. Economic Potential of Mining in Manitoba

Introduction

Base case results and time trends are examined in this chapter. The base case conditions, used as a standard of comparison with other variants, are:

- 56 possible economic base metal, gold and nickel deposits discovered in Manitoba during the 1946-88 period;
- expected metal price conditions;
- 8 percent cost of capital and minimum acceptable return for an economic deposit;
- $6-million annual exploration budget.

The text provides an overview of study findings. A more comprehensive set of average before-tax cash flow and expected value results can be found in Appendix VI. In each section, the appropriate table of results is footnoted in the text.

Mineral Exploration Economics[1]

[1] Table 10, Appendix VI.

Under base case conditions, 23 of the 56 deposits evaluated are found to be economic. The cost and revenue characteristics of these 23 economic deposits are used to assess the time distribution of average cash flows, illustrated in Figure 11. The undiscounted summation of the associated revenues and costs is shown in Figure 12. The net result is an average cash flow of $656 million generated per economic deposit.

Based on the time distribution of average cash flows for an economic deposit (Figure 11), assessments have been made of the expected value of mineral exploration in Manitoba. Base metal, gold, and nickel exploration represents an expenditure of approximately $1.1 billion, the result of which has been the discovery of 23 economic deposits. Therefore, the average cost required to find and delineate an economic deposit is about $46 million, equivalent to $34 million (E) when discounted at 8 percent to the start of the exploration phase. The reward for this exploration expenditure is an average return of $91 million (R) for each economic discovery. This return, the resultant of average development and production phase cash flows, is also expressed as a present value at the start of exploration. Consequently, the expected value of exploration per economic discovery is $91 million minus $34 million, or $57 million (EV). This means that, on average, based on the assumed conditions, $57 million of new wealth or economic surplus is associated with the discovery of an economic deposit. Alternatively, the expected value of exploration can be expressed as an 14 percent expected rate of return in relation to the 8 percent cost of capital.

Figure 11. Before-tax distribution of average cash flows for an economic deposit under base case conditions

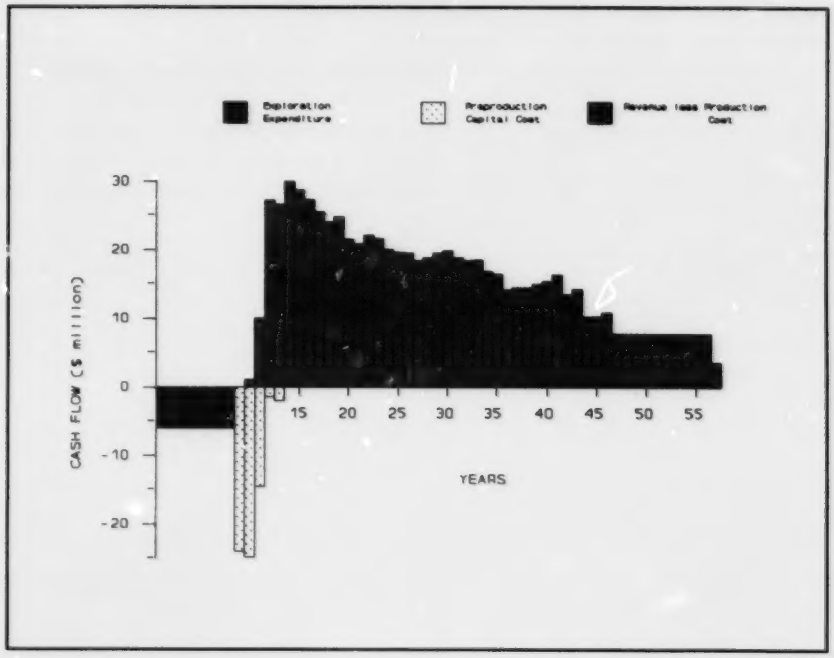
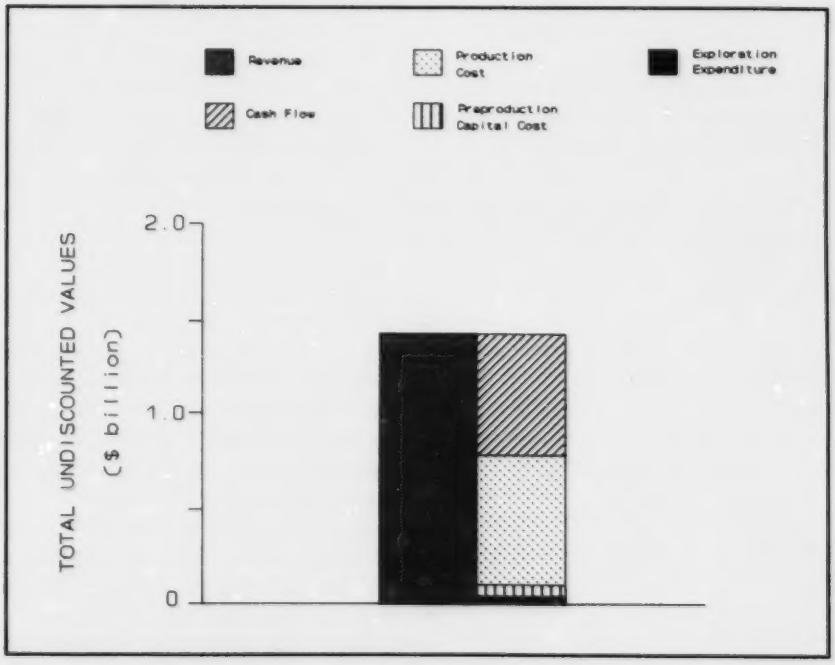


Figure 12. Total cash flow components for an economic deposit before tax under base case conditions

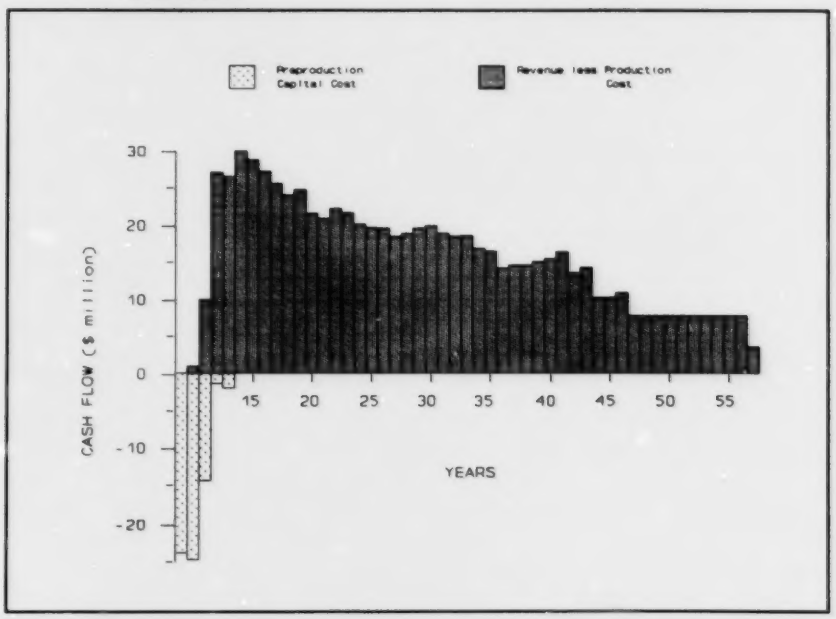


Base case results indicate that mineral exploration has the potential to substantially increase the net value or wealth available to Manitoba society.[9]

Mine Development Economics[10]

The time distribution of average cash flows for an economic deposit as viewed from the start of development is illustrated in Figure 13. This diagram reproduces the development and production phase cash flows already shown in Figure 11.

Figure 13. Before-tax time distribution of average cash flows for an economic deposit as viewed from the start of development under base case conditions



The economics of mine development can be characterized by the expected net present value of $165 million and the expected rate of return of 33 percent assessed from this cash flow distribution. Given an economic mineral deposit at the start of development, mining in Manitoba is shown to offer great potential for profitable investment and wealth creation.

The difference between the expected values of mine development – $165 million and 33 percent – and the expected values previously evaluated for mineral exploration – $57 million and 14 percent – provides an economic measure of exploration's contribution to the mineral supply process. Successful exploration is required to realize the enhanced economic returns offered at the start of development. This enhancement is the result of a selective, sequential information-gathering process that, starting with a broad exploration environment of interest (Manitoba in this case), resolves the discovery and geologic risks, finding and delineating a mineral deposit which has economic potential for development.

[9] The base case findings, as well as the results which follow for a wide range of variants, represent the average performance of all companies that have explored in Manitoba. Probably at least 80 percent of the companies exploring in particular exploration environments are never successful. When the costs associated with these failures are subtracted out of the exploration expenditure totals, a rich cost-risk-reward relationship remains for the few successful companies.

[10] Table 10, Appendix VI.

The cash flow distribution presented in Figure 13 averages together the cost and revenue characteristics for the 23 economic deposits assessed in Manitoba. These discoveries are listed in Table 6.[11] The economic potential of mine development is determined in each case by the deposit's particular characteristics. These are averaged together with other widely ranging sets of deposit characteristics to appraise the composite "typical" deposit profile shown in Figure 13.

[11] For base case conditions, this list answers our question: Which of the historical discoveries represent economic exploration targets to find and delineate today? Note that some successful past producers do not make the list. On the other hand, several deposits which were not or are yet to become successful mines do appear. These apparent anomalies are explained by the basic difference between the current outlook economic and technological conditions applied in the study, and the actual historical experiences and conditions which have prevailed.

Table 6. Economic deposits assessed in Manitoba under base case conditions

Base Metal Deposits	Gold Deposits	Nickel Deposits
Callinan	Burnt Timber	Birchtree
Chisel Lake	Farley Lake	Bucko Lake
Chisel North	Puffy Lake	Lynn Lake
Fox		Namew Lake
Ghost Lake		Pipe 2
North Star		Thompson 1D
Rod		Thompson Main
Ruttan		
Ruttan West		
Schist Lake		
Stall		
Trout Lake		
Westarm		

The high degree of variability in the returns associated with the development of economic discoveries – a consequence of the underlying variability in tonnage, grade, and other geologic characteristics among economic deposits – is an essential feature of the mineral supply process. To illustrate this variability, we have examined the cumulative frequency distributions of total revenue, net present value, and rate of return for the 23 economic deposits assessed in Manitoba under base case conditions. Key statistics from these distributions are summarized in Table 7.

Total revenue, evaluated in this case at the minesite, reflects deposit size. Table 7 indicates that there is a 58-times difference in size between the lower-decile and upper-decile economic deposits around the mean value of $1,439 million. The total revenue distribution is also shown to be highly skewed. There are many small economic discoveries and a few that are very large. Thus, the mean value for total revenue ($1,439 million) is higher than that of the upper-quartile deposit ($1,240 million), and almost four-times greater than the median or middle value of the distribution ($405 million).

Rate of return measures the profitability of an economic deposit. The rate of return distribution for the 23 economic deposits is shown in Table 7 to be less variable and not as skewed as the total revenue distribution. There is a 5-fold difference in rate of return between the lower-decile and upper-decile economic deposits (12 percent and 57 percent respectively). The mean rate of return is close to the upper-quartile value (32 percent).

Table 7. Variability of the return for economic deposits in Manitoba

Statistic	Total Revenue ($ million)	Net Present Value ($ million)	Rate of Return (percent)
Upper decile	3,869	380	57
Upper quartile	1,240	82	32
Mean (average)	1,439	165	32
Median	405	34	25
Lower quartile	145	14	18
Lower decile	67	8	12

Turning to the net present value results which provide an overall indicator of size and profitability characteristics, the mean or average value is $165 million. The variability of the return, given an economic deposit, is illustrated by the 48-fold difference in value between the lower-decile and upper-decile economic deposits ($8 million and $380 million respectively). Like the size distribution, the net present value distribution is highly skewed. There are many low-value economic discoveries and relatively few of extremely high value. As a consequence, the mean value of an economic deposits ($165 million) is twice as large as the upper-quartile value ($82 million).

With respect to government policy formulation, the main message conveyed by the results presented in Table 7 is that there is no such thing as a *typical deposit*. Thus, flexibility is required in government policies to accommodate realistically and efficiently the wide range of returns associated with mine development.

Time Trends in Economic Performance[12]

[12] Table 11, Appendix I.

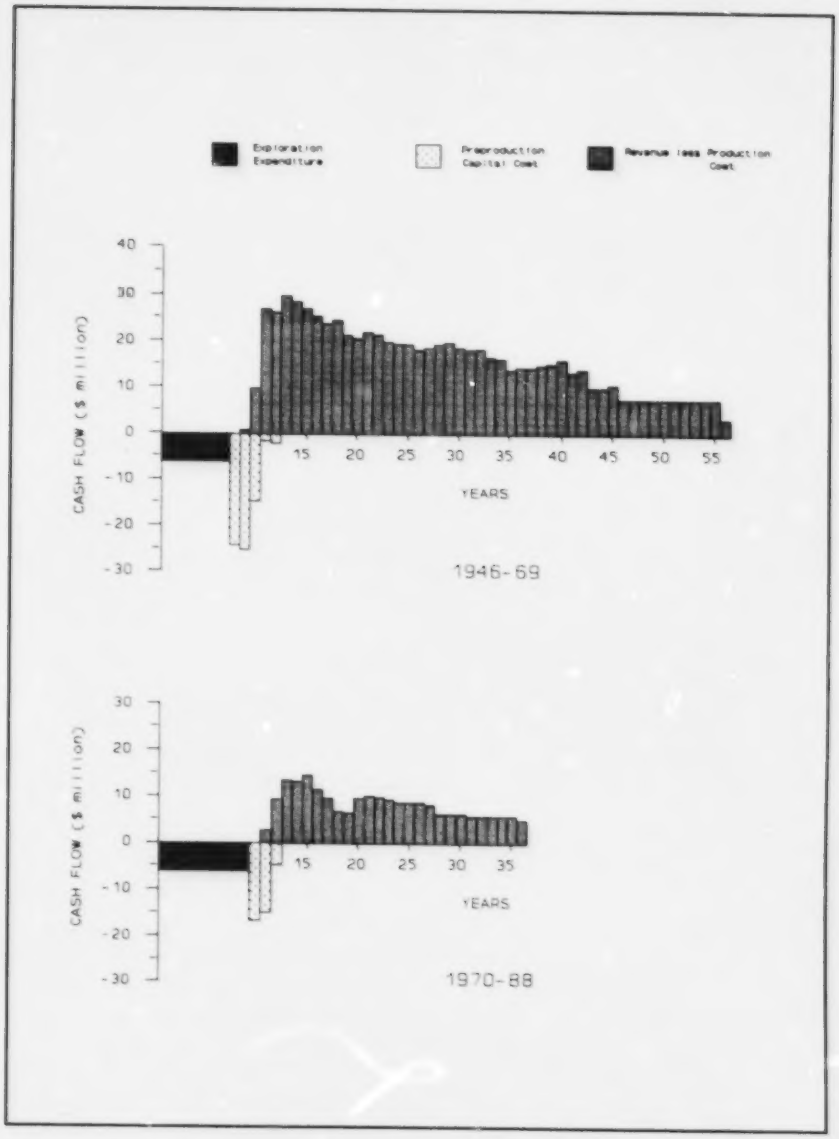
When using historical experience to support current policy and planning initiatives, it is important to try to detect time trends in the economic potential of mineral exploration and development. What changes have occurred in Manitoba over the 43-year study period? According to the methodology described in Chapter 2, time trends are the resultant of two main forces: depletion effects on the one hand, and the effects of improved geological concepts, advances in exploration technology, and changes in organizational efficiency on the other.[13] This dynamic aspect of the mineral supply process is now examined.

[13] These time trends do not take into account the real changes in mineral market conditions or the improvements in mining and mineral processing technologies and management practices which have taken place during the study period. In our evaluation, these factors are standardized on the basis of current outlook conditions. The intention is to isolate those aspects of the supply process which have resulted from the changing nature of exploration and from changes in mineral endowment characteristics as revealed through the deposits discovered.

Two time intervals have been selected as being most appropriate in Manitoba's case: a 24-year interval, 1946-69, followed by a 19-year interval, 1970-88. While this subdivision is somewhat arbitrary, it is intended to balance the need for a sufficient number of points to detect time changes (i.e. at least two), and the requirement for a meaningful sample size of exploration and discovery experience within each interval.

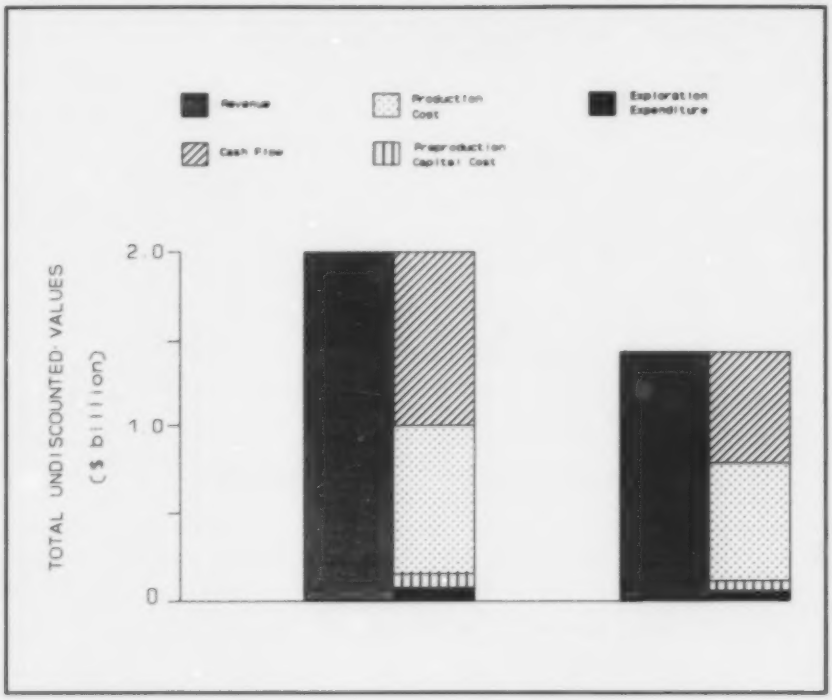
The time distributions of average cash flows for the two time intervals are presented in Figure 14 and summarized in Figure 15. A sharp deterioration is evident. The total cash flow generated by an economic deposit plummets from $1,004 million for the 1946-69 discoveries to $111 million on average during the 1970-88 interval.

Figure 14. Time distributions of average cash flows for an economic deposit by time interval



Time trends in the expected value of mineral exploration in Manitoba are illustrated in Figure 16. While exploration expenditures are fairly evenly split between the two intervals, there is a notable decline from 14 to 9 in the number of economic deposits found. Consequently, the average exploration expenditure per economic discovery increases from $40 million to $57 million. The marked deterioration in the expected value per economic discovery (EV) from $113 million to − $13 million is a consequence of two factors: higher discovery costs as noted above, and a sharp decrease in the average return

Figure 15. Total cash flow components for an economic deposit by time interval



[14] The negative EV finding for the 1970-88 interval indicates more money going into the ground in time-adjusted terms for exploration, development, and production costs than is realized from the associated sales revenues.

associated with the economic deposits discovered.[14] The decline shown in the expected rate of return from 18 to 6 relative to the 8 percent hurdle rate is also disturbing.

Figure 17 shows the related time trends in expected values as viewed from the start of development. The average net present value per economic discovery falls from $237 million to $53 million, and the associated rate of return declines from 34 percent to 27 percent. Thus, the economic deposits discovered in more recent years are typically much smaller and somewhat less profitable then those found from the late 1940s through the 1960s.

These unfavourable changes, which mainly reflect experience within the Flin Flon, Snow Lake and Thompson districts, provide clear evidence of depletion. The Flin Flon and Snow Lake areas, and to a lesser extent the Thompson nickel belt, have long histories of intensive exploration. They have the advantages of a successful track record and established infrastructure. Nevertheless, a dramatic improvement in exploration performance is called for during the 1990s to counter and reverse the negative historical trends. In order to succeed, the strategic direction of mineral exploration will have to shift quickly and persistently into new scientific, geographical, and organizational frontiers, including

- application of geological concepts and exploration technologies to cross "invisible" frontiers within the proven mining districts (Masters, 1989; Woodall, 1984). The Chisel North and Callinan discoveries point the way;

Figure 16. Time trends in expected values for mineral exploration

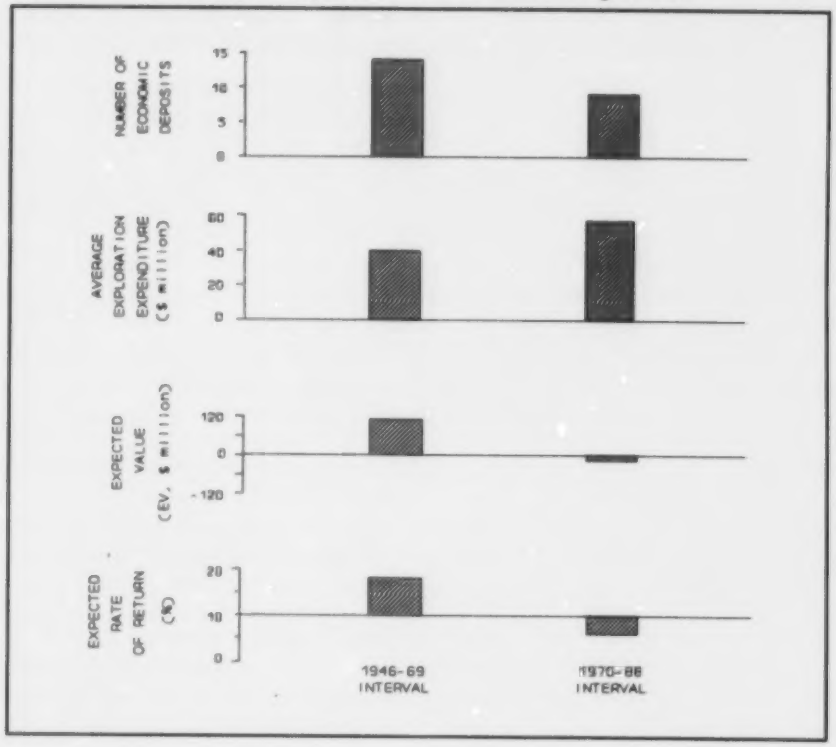
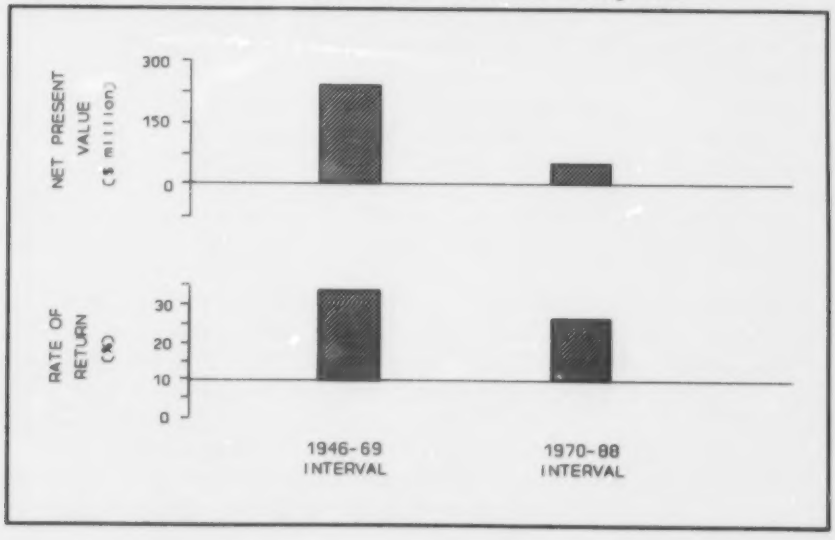


Figure 17. Time trends in expected values for mine development



- more attention to frontier regions which offer potential for undiscounted mining districts (Verleun and Mackenzie, 1988). Perhaps Manitoba's vast northeast hinterland can provide this type of long-term opportunity;
- create, nurture, and sustain forms of exploration organization which are capable of performing well above average (Woodall, 1984; Mackenzie, 1989).

Summing Up

The economic potential of mineral exploration and development in Manitoba is shown to be substantial. In the long term, as viewed from the start of exploration, Manitoba's mineral supply process is characterized by an expected value of $57 million per economic deposit discovered and by an 14 percent expected return on investment in relation to the 8 percent cost of capital considered.

In the medium term, the economic return characteristics at the start of mine development are typified by a net present value of $165 million per economic mineral deposit and by a 33 percent rate of return on investment. The enhancement in potential values which occurs between the start of exploration and the start of mine development illustrates exploration's strategic role in the mineral supply process.

A high degree of variability is shown in the return characteristics of individual economic deposits around the composite values appraised. These differences reflect the underlying variability in deposit size, grade, and other geological parameters among the economic discoveries.

A marked deterioration in economic performance is evident within the 1946-88 study period, reflecting the effects of depletion in the Flin Flon and Snow Lake areas, and in the Thompson nickel belt. In order to counter and reverse these unfavourable changes, a dramatic improvement in exploration performance is called for during the 1990s. In order to succeed, imaginative new geological models, exploration technologies, geographical directions, and organizational structures will have to be formulated and implemented.

5. Sensitivity of Potential Values to Key Study Parameters

Introduction

The potential value assessments presented in Chapter 4 are based on a particular set of base case conditions. We are uncertain about a number of the conditions assumed. In the present chapter, the more general validity of the base case findings is examined using sensitivity analysis. The key parameters selected for attention are

- metal prices;
- annual exploration budget rate;
- cost of capital;
- effect of an exploration-development time gap;
- exclusion of the multi-billion dollar discovery.

Once again, an overview of the study results is provided in the text. A more comprehensive set of findings is documented in Appendix VI. The appropriate table of detailed results is footnoted at the start of each section.

Metal Price Variants[15]

The expected metal prices used in Chapter 4 represent highly uncertain *best* estimates. The sensitivity of potential value assessments to the lower-limit and upper-limit metal price conditions specified in Table 4 are examined in this section.

Expected values for mineral exploration, presented in Figure 18, are highly sensitive to metal prices. As prices are increased from lower-limit to upper-limit levels, the number of economic deposits increases from 3 to 42. Consequently, the average undiscounted exploration cost per economic discovery drops by an order of magnitude from $355 million to $25 million. Accordingly, higher metal prices greatly reduce the average time required to discover and delineate an economic deposit.[16] The net result is that the time-adjusted exploration expenditure associated with an economic deposit (E) declines from $74 million to $21 million.[17]

Mineral exploration, very uneconomic at lower-limit prices and decidedly economic at expected prices, is found to have great wealth-creating potential at upper-limit prices. Under this optimistic market scenario, the expected value per economic deposit is $196 million and the expected rate of return is 27 percent (Figure 18).

Figure 19 illustrates the associated assessments of expected values as viewed from the start of mine development. As metal prices are increased, two partially offsetting economic forces are at work:

[15] Table 12, Appendix VI. Time trend results at lower-limit and upper-limit prices can be found in Tables 13 and 14, respectively.

[16] This is because more discoveries satisfy the definition of an *economic deposit*. It is not due to integral change in the exploration process.

[17] Note that Figure 18 and similar illustrations which follow depict the *undiscounted* exploration expenditure per economic discovery.

Figure 18. Expected values for mineral exploration as a function of metal price

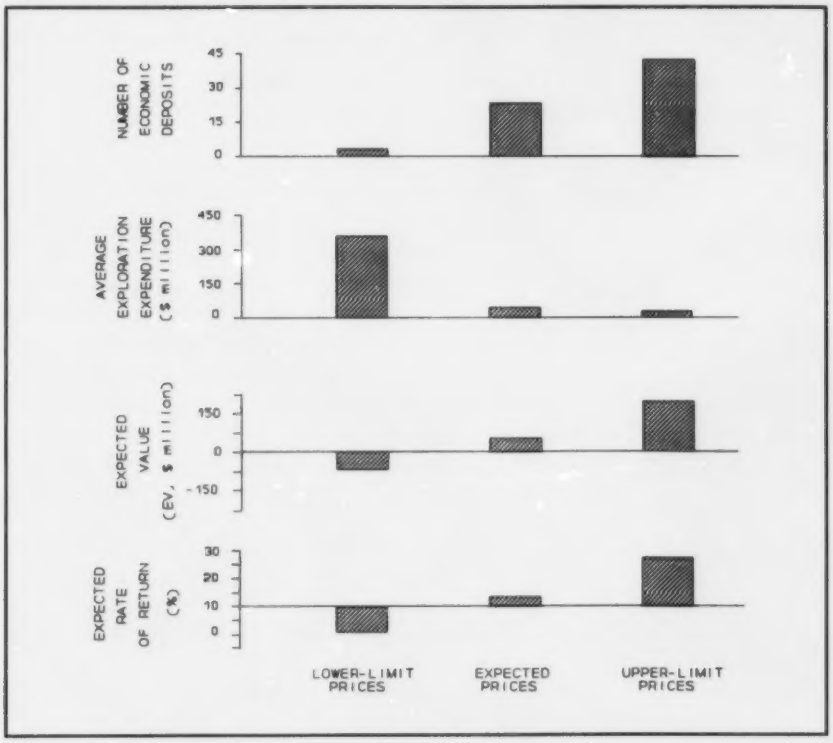
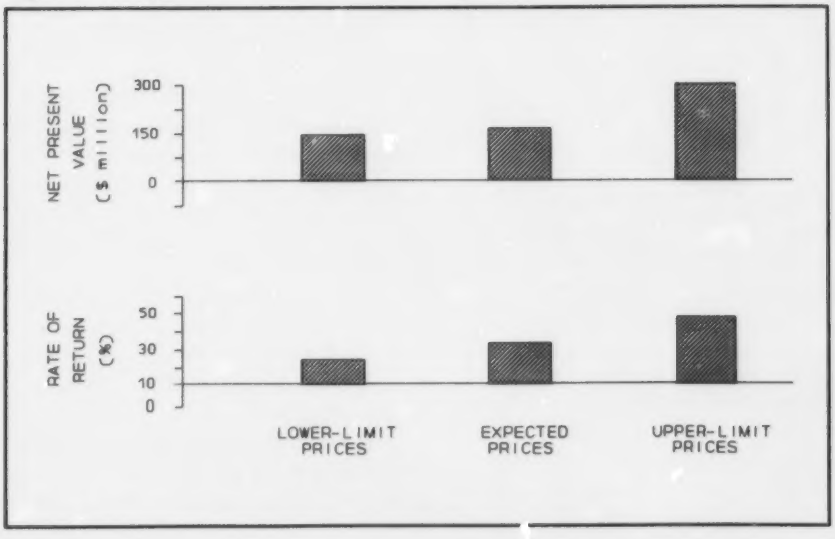


Figure 19. Expected values for mine development as a function of metal price



- the direct effect of higher prices on enhancing sales revenue;
- the dilution effect associated with including more marginal economic deposits.

The price effect is shown in Figure 19 to outweigh the dilution effect throughout the range of prices examined. Consequently, as prices rise from lower-limit to upper-limit levels, the average net present value per economic deposit increases from $146 million to $300 million, and the average rate of return is enhanced from 25 percent to 48 percent.

The findings presented here demonstrate that the uncertainty associated with metal price forecasts represents a critical bottom-line risk in long-term corporate planning and government policy analysis. As we have seen, the potential of mineral exploration ranges from being hopelessly uneconomic to a bonanza, depending on which set of future metal prices is employed. Flexibility is obviously of the utmost importance in plans and policies to accommodate the resolution of price uncertainties with time.

Variants with Respect to the Annual Exploration Budget[18]

[18] Table 15, Appendix VI.

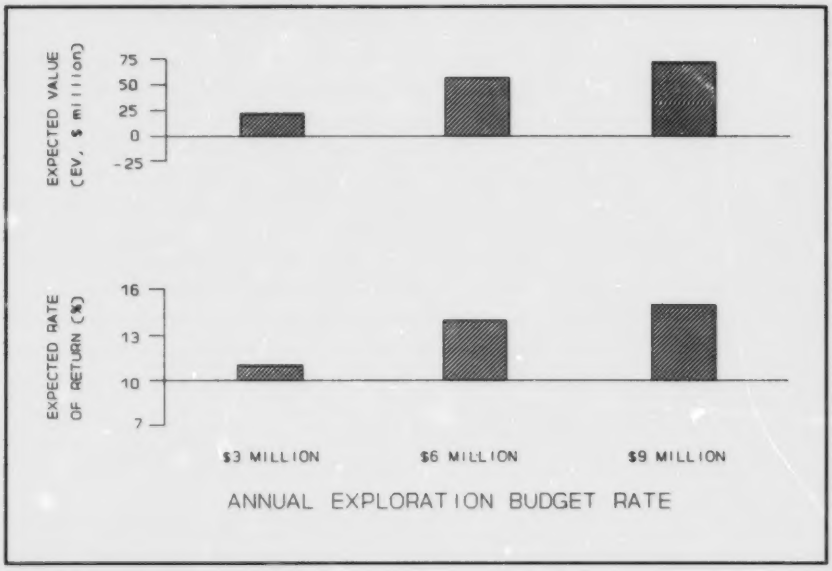
An annual exploration budget rate of $6 million, considered to be among the most efficient rates of expenditure for an exploration organization (Chapter 3), is incorporated in the evaluation carried out in Chapter 4. This assumption influences the expected value measures because it is a determinant of the average time required to discover and delineate economic deposit. At the $6-million rate of expenditure, we estimated that 8 years of exploration would be required on average for an economic deposit in Manitoba.

Assessments of the economics of exploration have also been made for annual exploration budgets of $3 million and $9 million. The effects of these budget rates on the expected value indicators are shown in Figure 20.

By reducing the average exploration time required for an economic deposit, the time distribution of negative cash flows is shortened and the distribution of positive cash flows moves towards the present. Thus, although the average undiscounted exploration expenditure per economic discovery remains constant, a significant improvement in the time-adjusted measures of performance is apparent. For example, the expected rate of return rises from 11 percent to 15 percent as the annual exploration budget rate is increased from $3 million to $9 million.

However, it should be noted that the apparent improvement in expected values may not, in fact, be realized if the actual exploration budget exceeds the most efficient annual rate. Large bureaucratic exploration organizations are characterized by high rates of expenditure and low levels of success. Thus, increasing the annual exploration budget beyond the most efficient size could well be counterproductive.

Figure 20. Expected values for mineral exploration as a function of the annual exploration budget



[19] Table 16, Appendix VI.

Cost of Capital Variants[19]

A constant money cost of capital of 8 percent is used in the base case to evaluate the economic potential of mining in Manitoba. To analyze the sensitivity of study results to the cost of capital, assessments are also made for 5 percent, 12 percent, and 15 percent rates.

The impact of the cost of capital on expected values as viewed from the start of exploration is illustrated in Figure 21. Raising the rate-of-return threshold from 5 percent to 15 percent reduces the number of economic deposits from 23 to 19, demonstrating that a significant number of discoveries lie close to the investment margin, as already indicated (Table 6). Consequently, the average exploration expenditure per economic discovery increases from $46 million to $56 million. The overall economic potential of exploration deteriorates from highly positive EV and rate of return results at the 5 percent cost of capital, to an essentially breakeven situation at 12 percent and, then to negative expected values as the cost of capital is increased further to 15 percent. Given a corporate hurdle rate of 15 percent, mineral exploration characteristically would be an uneconomic endeavour.

The effect of cost of capital on the economic indicators at the start of development is shown in Figure 22. As the cost of capital is elevated from 5 percent to 15 percent, the average net present value per economic deposit is reduced substantially from $264 million to $80 million. Although the average rate of return increases from 33 to 40 percent as the marginal deposit situations are eliminated, the differential between rate of return and cost of capital narrows from 28 percent (33% − 5%) to 25 percent (40% − 15%), reducing the potential value of mine development.

Figure 21. Expected values for mineral exploration as a function of the cost of capital

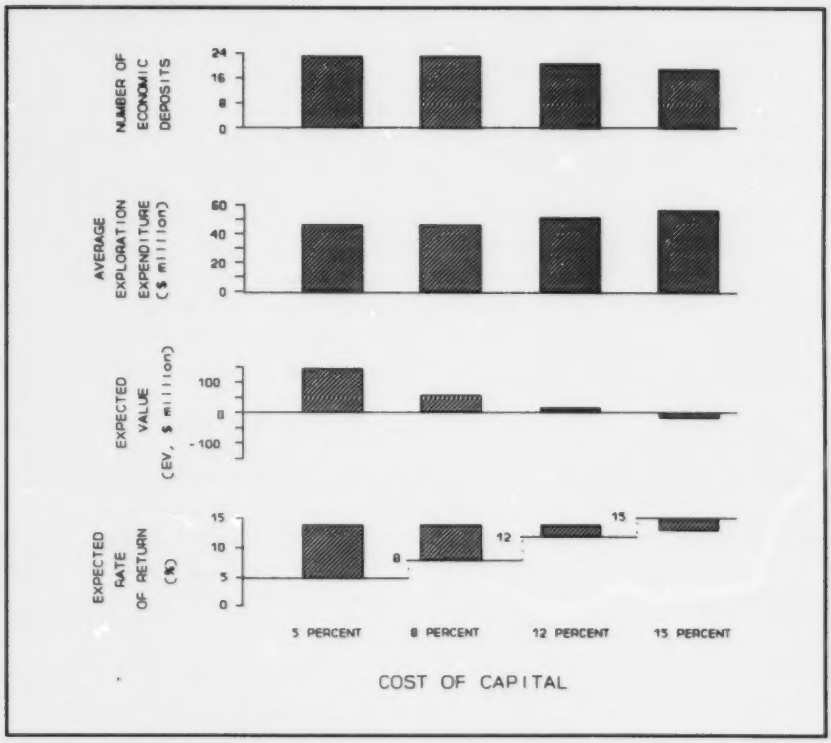
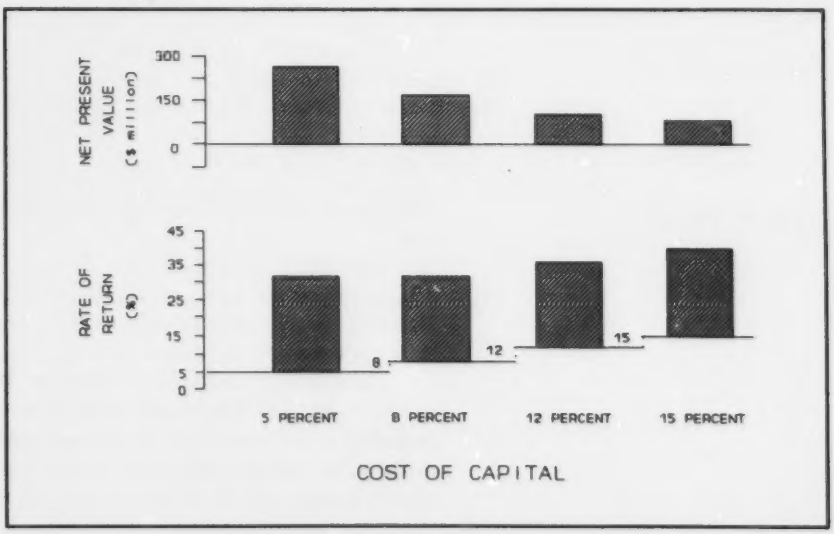


Figure 22. Expected values for mine development as a function of the cost of capital



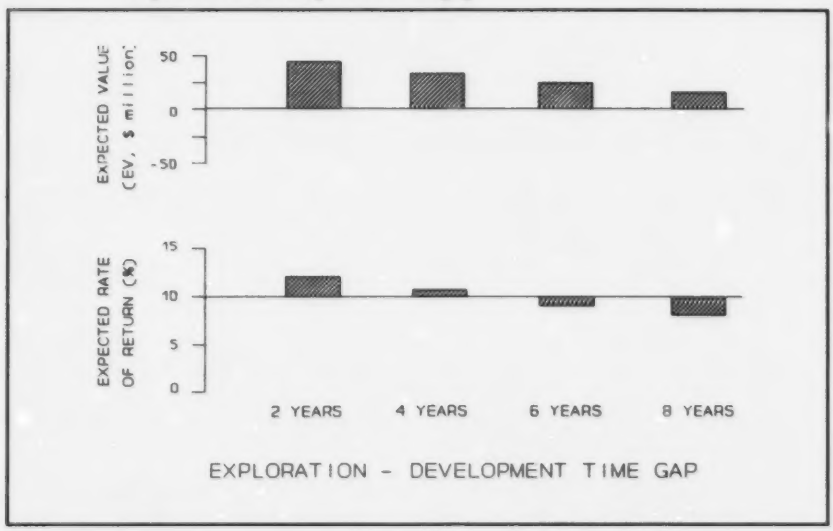
[20] Table 17, Appendix VI.

Effect of an Exploration-Development Time Gap[20]

The base case conditions assume that the delineation of an economic mineral deposit leads directly to mine development. In reality, unanticipated delays are often encountered between completing exploration and initiating development. Additional time may be required for further metallurgical or geological testing, environmental studies, preparation of impact statements, public hearings, and securing government approvals.

Figure 23 illustrates the effect of exploration-development time gaps of 2 years, 4 years, 6 years, and 8 years on the economic potential of mineral exploration. Such delays push the return from successful exploration further out into the future, making the search for economic deposits less prospective. As the gap lengthens to 8 years, the expected rate of return, for instance, declines from 14 percent to 8 percent. Mineral exploration, strongly economic under base case conditions, becomes little more than a breakeven proposition.

Figure 23. Expected values for mineral exploration, showing the effect of an exploration-development time gap



[21] Table 18, Appendix VI.

Exclusion of the Multi-Billion Dollar Discovery[21]

The Thompson Main nickel deposit is the most important economic mineral deposit discovered in Manitoba during the study period. The impact of this discovery on the potential values of exploration and development is examined by hypothetically removing it from the Manitoba database.

Comparative results as viewed from the start of exploration are illustrated in Figure 24. The Thompson Main discovery, only one of 23 economic deposits evaluated in the base case, has an inconsequential effect on the average exploration cost associated with an economic discovery. Its impact on the expected value indicators is, however, shown to be more substantial. Without

Thompson Main, the expected value per economic discovery would decline from $57 million to $11 million and the expected rate of return would be reduced from 14 to 9 percent.

The sensitivity of average mine development characteristics to this multi-billion dollar deposit is presented in Figure 25. Without Thompson Main, the average net present value for an economic deposit would fall from $165 million to $86 million, a substantial difference considering that the averaging is taking place across so many deposits. Similarly, the average rate of return on mine development investment would be reduced from 33 to 24 percent.[22]

The possibility that any exploration program can lead to a Thompson Main type of discovery, although extremely improbable, is undoubtedly a great motivating force in mineral exploration. Exceptional targets of this type likely carry weight in exploration decisions beyond their actual numerical contribution to the expected value measures.

[22] These findings are consistent with those obtained in a similar study for Ontario (Mackenzie, Bilodeau and Doggett, 1989). In this case, the Kidd Creek base metal deposit and the Hemlo gold deposits were found to make the difference between Ontario being a highly prospective and profitable province for exploration and what would otherwise be a marginal investment environment on average.

Summing Up

Mineral exploration in Manitoba was found to be a wealth-creating endeavour for the base case conditions evaluated in Chapter 4. We have now tested the sensitivity of this finding to realistic ranges of possible conditions for several key study parameters.

Mineral exploration would be uneconomic for the following conditions examined:

- lower-limit metal prices;
- 15 percent cost of capital.

Also, as highlighted in Chapter 4, uneconomic exploration performance typifies the 1970-88 time interval. Otherwise, exploration in Manitoba would be an economic endeavour overall.

The economics of mineral exploration and mine development are found to be particularly sensitive to future metal prices. Flexibility is of the utmost importance in exploration plans and policies to accommodate the resolution of international price and exchange rate market uncertainties with time.

The results presented also demonstrate that the economics of exploration are very sensitive to the cost of capital. The imposition of arbitrarily high thresholds has a counterproductive impact. Finally, the multi-billion dollar discovery, illustrated here by Thompson Main, is shown to have a critical impact on the overall economic prospects of mineral exploration.

Figure 24. Expected values for mineral exploration, showing the effect of the multi-billion dollar discovery

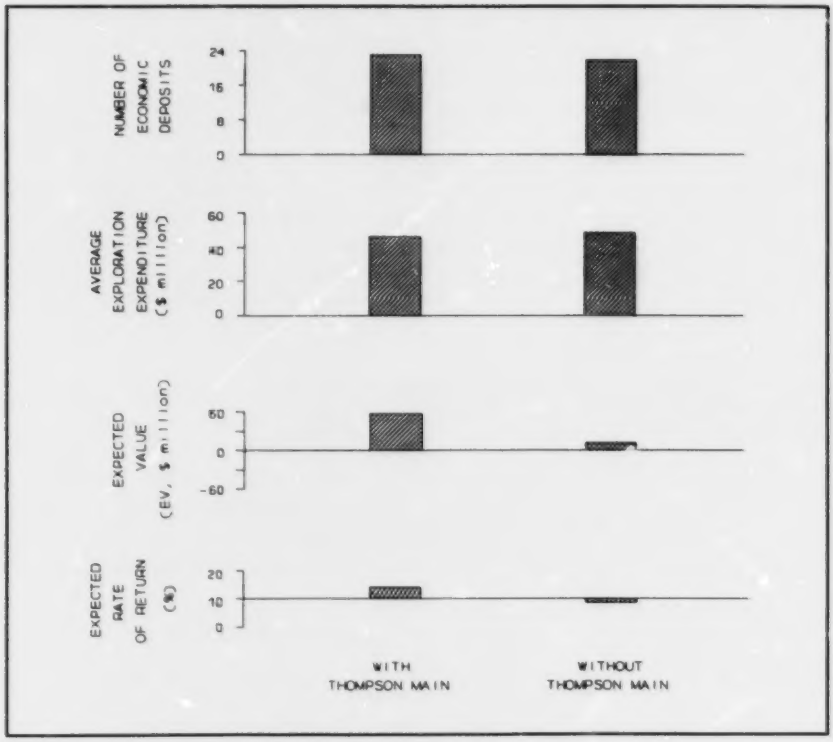
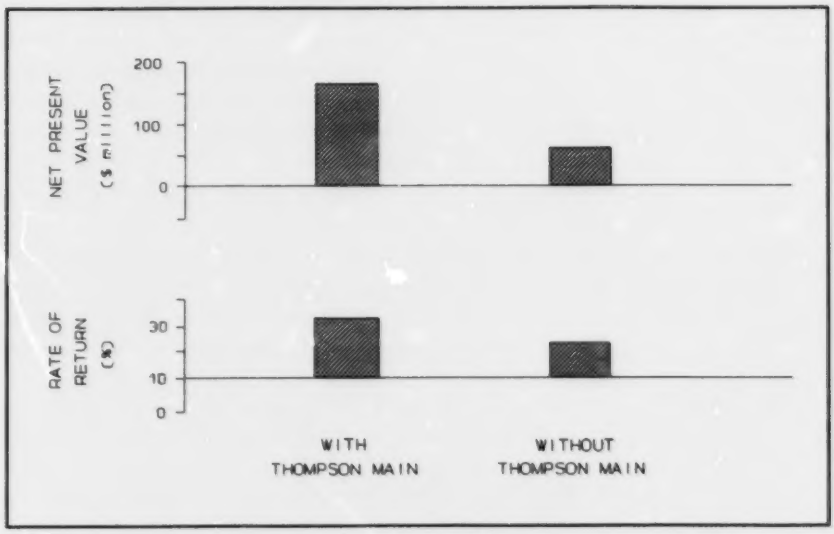


Figure 25. Expected values for mine development, showing the effect of the multi-billion dollar discovery



6. Impact of Taxation on Mining in Manitoba

Introduction

Chapters 4 and 5 have presented and analyzed the potential, before-tax value of mining in Manitoba. It is now appropriate to evaluate what these assessments mean in terms of after-tax incentive to the mining company contemplating investment in mineral exploration and mine development. At the same time, we can measure associated taxation criteria from a government policy viewpoint. The individual and combined impact of three profit-based taxes are considered: federal corporate income tax, provincial corporate income tax, and provincial mining tax and royalty.

The purpose of this chapter is to examine the effects of the income and mining taxation systems operative in Manitoba during 1991. Thus, these tax systems are overlaid on the potential value assessments, and indicators of after-tax investment incentive and taxation criteria are derived. An outline of the Manitoba taxation systems applied is given in Appendix VII. Comprehensive results for the after-tax cash flow characteristics and expected values for an economic deposit, and the associated mining taxation criteria, are presented in Appendix VIII.

First, a more general description of the tax assumptions and criteria used in Chapters 6-9 is provided.

Taxation Assumptions

Inflation

The existence of inflation complicates the evaluation of mining taxation effects. This is the result of two factors. First, the write-off of capital costs for tax purposes is permitted only over future periods of time. Tax allowances are taken against the current money income realized in those future time periods. Second, the amount which can be written off is limited to the actual capital costs incurred. Consequently, inflation diminishes the real constant-money benefits of tax write-offs. Thus, inflation reduces investment incentive and increases government tax revenues in real terms. The higher the rate of inflation, the stronger these effects will be.

It is therefore necessary to consider inflation in order to correctly determine the impact of taxation. A 5 percent annual rate of inflation is assumed for study purposes.

Exploration Expenditures

The mining taxation systems outlined in Appendix VII generally permit the *expensing* of exploration expenditures against current income as they are incurred.[23] This study does not consider the carry-forward of exploration expenditures for write-off against production income from economic deposits. Larger organizations are assumed to have sufficient income from other sources to be able to deduct exploration expenditures as they are incurred, receiving tax credits at the prevailing rate of taxation. Smaller enterprises which have no existing income and, therefore, receive no direct tax benefit from their exploration expenditure, are considered to qualify for an equivalent indirect tax credit through mechanisms such as the federal government's flow-through-share policy.

Therefore, the study assumes that all exploration expenditures are expensed for tax purposes.

[23] When we say that exploration expenditures are *expensed* for tax purposes, we mean that they are deducted from a company's income in the year expended for purposes of computing taxable income. This, for example, is the same way that operating costs are treated for tax purposes.

Development and Production Phases

Mining taxation allowances for the development and production phases can, generally speaking, be taken either on an *individual project* basis or on an *integrated company* basis. With the individual project (or stand-alone) basis of taxation, deductions can be taken only against production income from the project being evaluated. By *integrated company* we mean a mining company with existing sources of income from other projects. With the integrated company (or flow-through) basis of taxation, allowable deductions can be written off as rapidly as possible against other corporate income. The tax credits realized on an integrated company basis will, therefore, be more immediate than on an individual project basis. Conversely, the effective tax rate will be lower.

The extent to which the integrated company basis of taxation is applicable depends on several factors.

- Level of corporate income. If the projects being evaluated are large, anticipated corporate income from other sources may be insufficient to fully absorb allowable tax deductions from the project.
- Source of corporate income. The timing of deductions is further constrained by where the anticipated income comes from and by the type of income. For example,
  - income in Canada is required to take deductions for federal corporate income tax;
  - income in Manitoba is required to apply write-offs for Manitoba corporate income tax;
  - *mining* income in Manitoba is needed for a company to use deductions to reduce Manitoba mining tax payments.
- Government policy constraints. Taxation rules may further limit the degree to which corporate income can be "pooled" and deductions taken.

The actual tax treatment of mining projects varies through a wide range, from the individual-project situation on the one hand to the fully integrated-company scenario on the other. While it would be interesting to examine the sensitivity of project economics and effective tax rates to different degrees of deductibility against other corporate income, we have not attempted to do so here.

The study assumes that the representative mining projects are taxed on an *individual project* basis. Thus, the company concerned is considered to be a new entrant with no other relevant anticipated source of income. The tax treatment of integrated companies such as Inco and Hudson Bay Mining and Smelting would be somewhat more favourable than evaluated here.

Taxation Criteria

The taxation criteria outlined below are intended to measure the characteristics of mineral exploration and development in Manitoba from a public sector, government revenue, mineral policy perspective. These criteria are assessed both in the long term from the start of exploration and in the medium term from the start of mine development.

Government Tax Revenues

A time distribution of average tax credits during exploration and average tax payments during production is calculated in order to determine the after-tax time distribution of average cash flows for an economic deposit. This tax credit and payment stream is given direct attention here.

In each case, summation of the projected stream gives the average *net undiscounted tax revenues* for an economic deposit. The tax credit and payment stream is also time-adjusted to either the start of exploration or the start of development at the assumed cost-of-capital rate in order to determine the average *net tax revenues discounted at 8 percent* for an economic deposit.

The components of government tax revenues – federal income tax, provincial income tax, and provincial mining tax and royalty – are also compiled on the same undiscounted and discounted bases as the totals. The following three taxation criteria are derived from these assessments of government tax revenues.

Effective Tax Rates

The impact of taxation on the economics of mining can be measured by the *effective tax rate*. For study purposes, the effective tax rate is defined as the net discounted tax revenues divided by actual value realized – the summation of the net discounted tax revenues and either the after-tax expected value at the start of exploration (EV), or the after-tax net present value at the start of development. Overall effective tax rates are appraised using total tax payments. It is also of interest to examine the breakdown of this overall rate among the three tax components.

The effective tax rate provides a clear indication of the burden of taxes imposed in each case. Differences in the effective tax rate among jurisdictions reflect differences in competitive standing.[24]

Intergovernmental Tax Shares

Another policy issue concerns the division of tax revenues between the federal and provincial levels of government. Tax revenues, time-adjusted to either the start of exploration or the start of development at the cost-of-capital rate, provide the basis in this study for determining inter-governmental tax shares. The respective Canadian and Manitoba governments shares are in each case expressed as a percentage of total tax revenues.

Comparative Tax Levels

In order to directly address the competitive position issue, the incidence of taxation in Manitoba is compared with other Canadian jurisdictions and for several Manitoba mining tax options. Comparative tax levels are determined on the basis of the average tax payments for an economic deposit, time-adjusted to either the start of exploration or the start of development.

Government tax revenues collected in Manitoba under the existing tax system are assigned an index of 100. Tax payment indexes for the other cases are then measured relative to this base. Comparative tax levels are calculated for total taxes paid, as well as for each of the three components which make up this composite picture.

Uneconomic Situations

The before- and after-tax evaluation results include lower-limit price cases which are found to be uneconomic. For the determination of the above taxation criteria, it is considered appropriate to restrict attention to only those situations which would be economic on an after-tax basis. After all, these are the only circumstances which would justify investment in mine development, with its associated generation of taxable income.

After-Tax Evaluation of Mineral Exploration[25]

The after-tax base case conditions, to which other results are compared, include those already specified in Chapter 4 for the assessment of potential value. In addition, the following taxation conditions, discussed above, are embodied in the base case:

- 1991 Manitoba and federal government taxation systems;
- general rate of inflation of 5 percent;

[24] The effective tax rate as defined here is an *average* rate. This criterion should be clearly distinguished from the *marginal* effective tax rate as employed, for example, in Boadway, McKenzie and Mintz (1989).

The *marginal* rate is based on the amount of tax which would be paid on the income generated from the last increment of investment (i.e. the marginal increment) in a project. This approach is suited to measuring the extent to which taxation may distort the optimization of development specifications and investment for projects. While this is an important type of policy issue, the level of detail required for meaningful empirical analysis, including the estimation of production functions for the projects to be examined, is beyond the scope of the present study.

Our study focuses on the effect of taxation on Manitoba's competitive position. We have chosen to use the *average* tax rate because it provides a comprehensive measure of comparative tax levels among jurisdictions and, therefore, is a worthwhile indicator of the tax component of competitive standing. Of course, high average tax rates may reflect, in part, high economic returns earned on projects. Even though average rates of tax are high, sufficient incentive may remain to undertake differences in competitive position.

Within our modelling constraints, we also are interested in the distorting effects of taxation on the economic viability of projects and investment decisions. This issue is addressed by employing discounted-cash-flow criteria to highlight those mining project situations which, while potentially economic to develop, would not justify investment on an after-tax basis.

[25] Tables 19 and 20, Appendix VIII.

- 100 percent expensing of exploration expenditures for tax purposes;
- individual-project basis of taxation for development and production phases.

Under these conditions, the number of economic deposits is reduced from 23 to 19. Thus, one-sixth of the potentially economic deposits are rendered uneconomic by the taxation systems currently operative in Manitoba. This highlights an important inefficiency in existing government policy.

The cost and revenue characteristics of these 19 economic deposits are used to assess the after-tax time distribution of average cash flows for an economic deposit, illustrated in Figure 26. The total undiscounted cash flow components are shown in Figure 27. Thus, on average, the after-tax cash flow associated with an economic deposit is $340 million, compared to $656 million before tax.

Figure 28 summarizes the after-tax expected values for mineral exploration under base case conditions. The undiscounted exploration expenditure per economic discovery increases from $46 million to $56 million. However, the average exploration expenditure required to find and delineate an economic deposit (E), after receiving the associated tax credits and being time-adjusted to the start of exploration, is reduced to $13 million. However, the average return from an economic deposit (R) is also cut down, from $91 million to $38 million. Consequently, the expected value per economic deposit, portrayed in Figure 28, falls from (91 − 34) = $57 million before tax to (38 − 13) = $25 million on an after-tax basis. The corresponding expected after-tax rate of return is 13 percent as compared to the 14 percent potential rate of return. The reduction in rate of return is less pronounced because, at this discount rate, the present value of exploration tax credits largely offsets the present value of the tax liabilities incurred during production.

With respect to the taxation criteria, the net undiscounted tax revenues per economic deposit, illustrated in Figures 26 and 27, total $397 million. When the time distribution of taxes is discounted at 8 percent to the start of exploration, it is equivalent to $31 million, comprising

- $11 million of federal income tax;
- $6 million of Manitoba income tax;
- $14 million of Manitoba mining tax.

The overall effective tax rate is 55 percent, made up of

- a 20 percent federal income tax rate;
- a 11 percent Manitoba income tax rate;
- a 24 percent Manitoba mining tax rate.

The Manitoba government receives 65 percent of the tax revenues, with the remaining 35 percent going to the federal government.

After-Tax Evaluation of Mine Development[26]

Turning now to the impact of taxation on the economics of mine development, the after-tax expected values are portrayed in Figure 29. The expected net

[26] Tables 19 and 20, Appendix VIII.

Figure 26. After-tax time distribution of average cash flows for an economic deposit under base case conditions

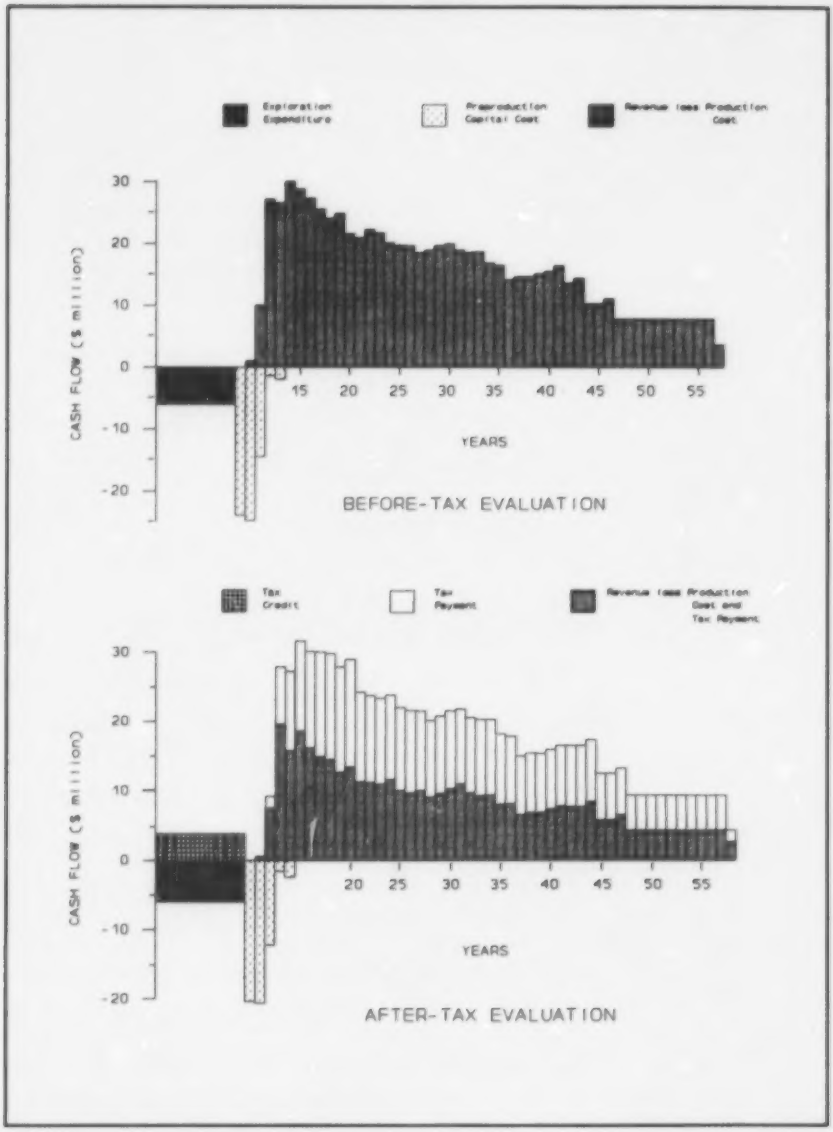
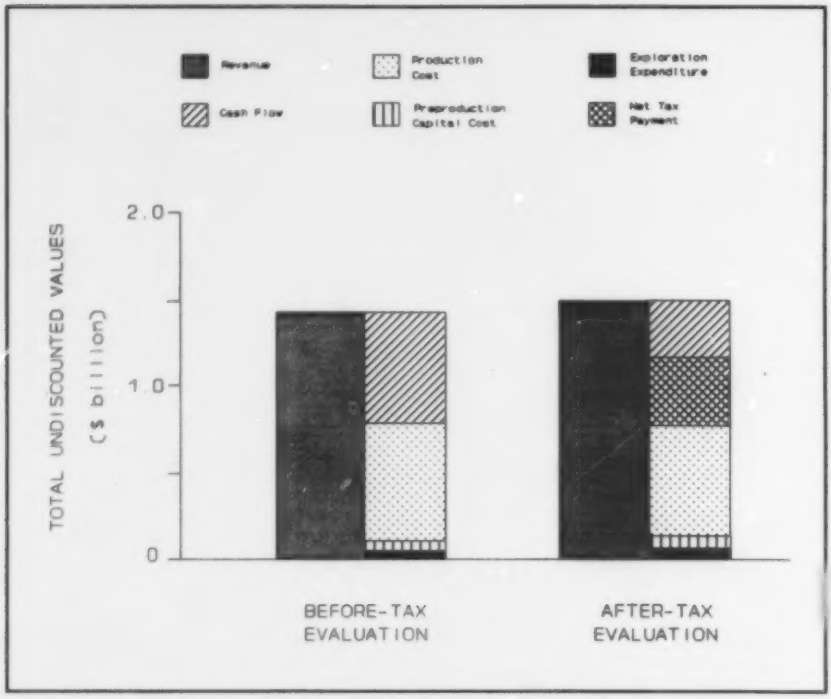


Figure 27. Total cash flow components for an economic deposit after tax under base case conditions



present value per economic deposit is reduced from $165 million before tax to $77 million after tax, and the expected rate of return declines from 33 percent to 24 percent. Tax revenues average $434 million per economic deposit, equivalent to $115 million when time-adjusted to the start of development, comprising

- $45 million of federal income tax;
- $27 million of Manitoba income tax;
- $43 million of Manitoba mining tax.

The overall effective tax rate of 60 percent is significantly higher than the 55 percent which applies from the start of exploration because the exploration-phase tax credits are no longer a relevant consideration for evaluation purposes. From this medium-term perspective, the Manitoba government collects 61 percent of the time-adjusted tax revenues.

Metal Price Variants[27]

The after-tax expected values for mineral exploration as a function of metal price are shown in Figure 30.

[27] Tables 21-23, Appendix VIII.

Figure 28. After-tax expected values for mineral exploration under base case conditions

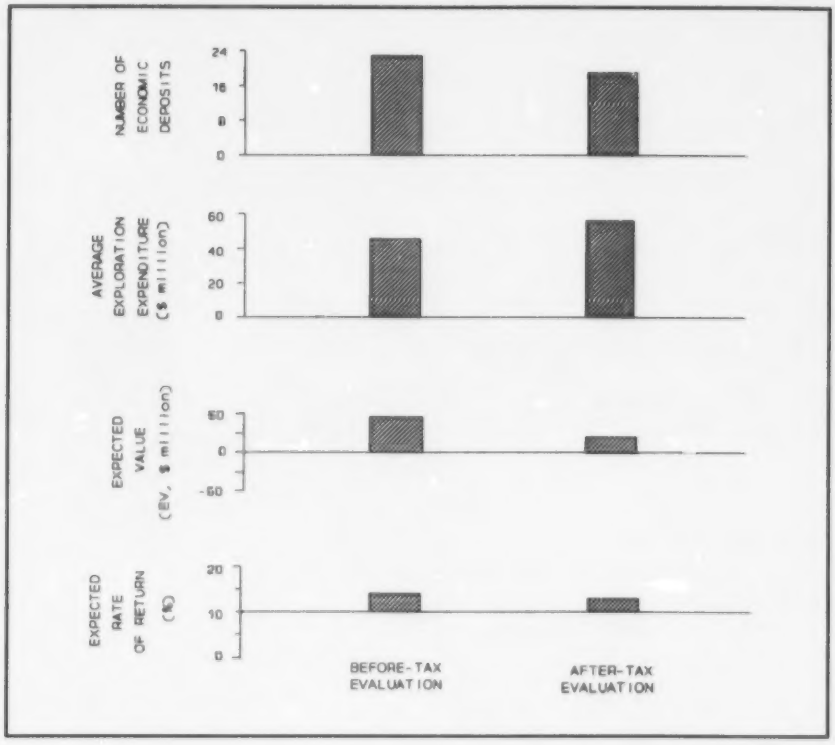


Figure 29. After-tax expected values for mine development under base case conditions

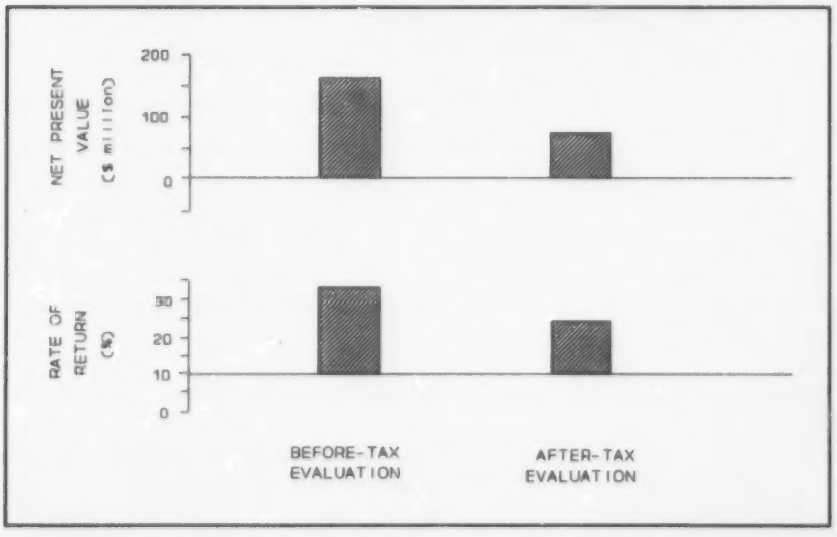
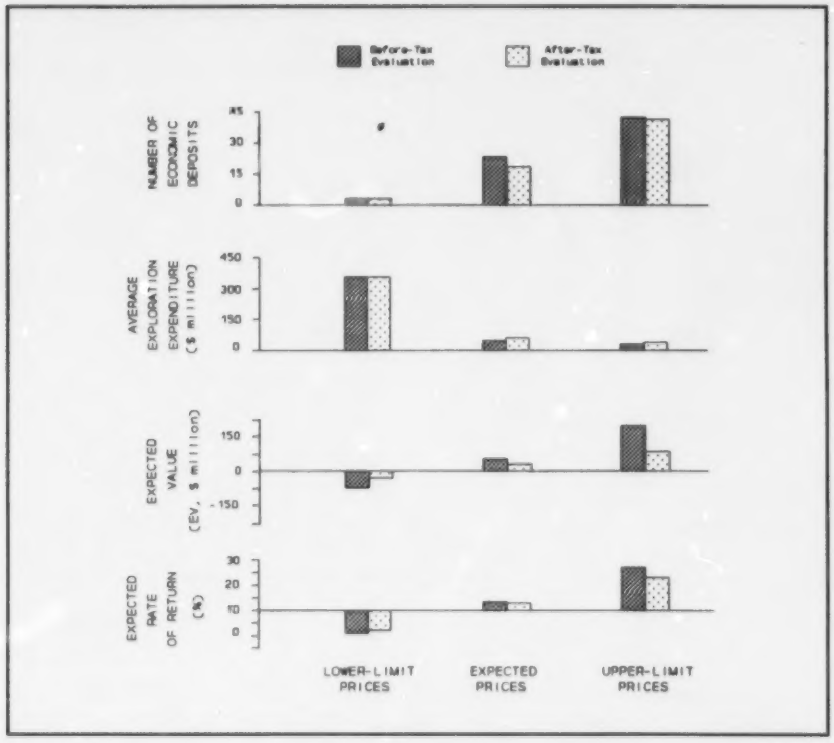


Figure 30. After-tax expected values for mineral exploration as a function of metal price



Taxation reduces the number of deposits which would be economic at both expected and upper-limit price levels. The effect of taxation on the expected value of exploration at upper-limit prices is substantial. Nevertheless, a very positive incentive for investment remains.

Figure 31 illustrates two of the associated taxation criteria. As prices rise from expected to upper-limit levels, discounted tax revenues per economic deposit more than triple, from $31 million to $114 million. The effective overall tax rate increases from 55 to 57 percent.

The after-tax expected values for mine development are presented in Figure 32, and the associated tax criteria in Figure 33. Despite the high tax burdens imposed, investment in new mine development remains economic over the entire range of prices analyzed. A substantial decrease in the net discounted tax revenue per economic deposit is shown in Figure 33. This is attributable to the superior characteristics of the three deposits which remain economic at lower-limit prices relative to the 16 discoveries which are added between the lower-limit and expected price levels. The effective tax rate is found to decrease from 69 percent at lower-limit prices to 58 percent under base case conditions. A decrease in the rate of taxation as a function of profitability, as illustrated here, is symptomatic of a regressive tax system.

Figure 31. Taxation criteria from the start of exploration as a function of metal price

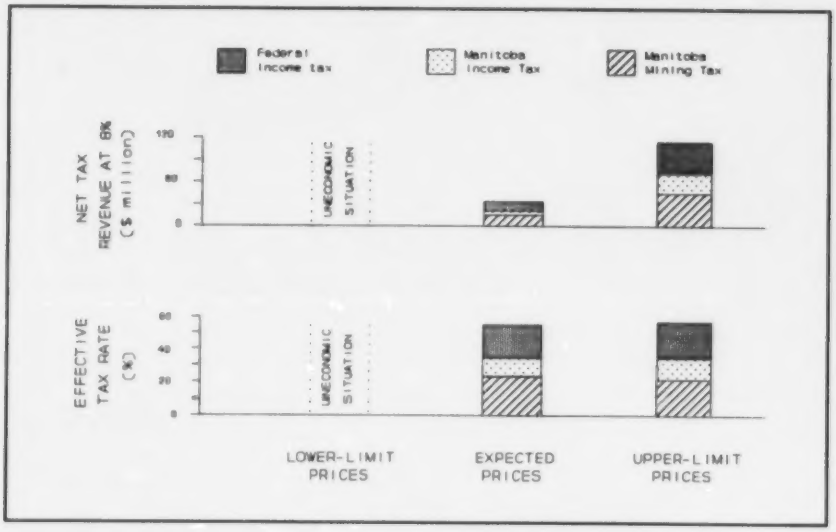


Figure 32. After-tax expected values for mine development as a function of metal price

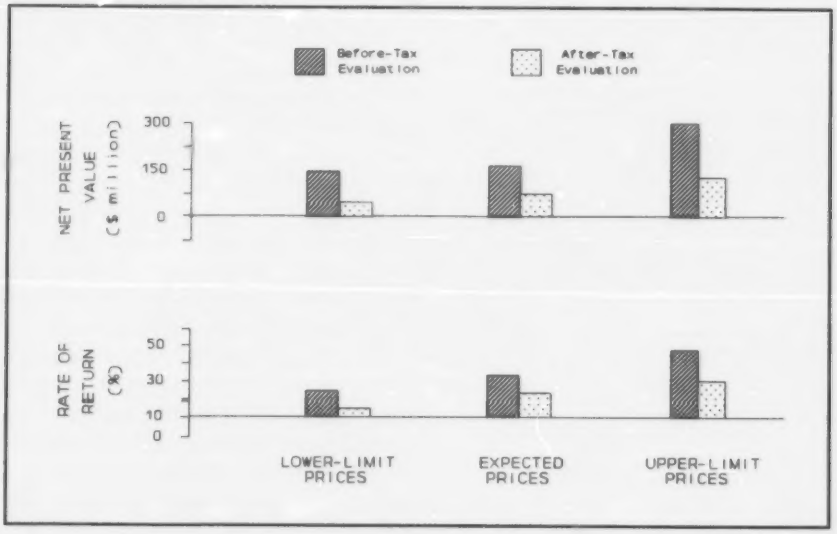
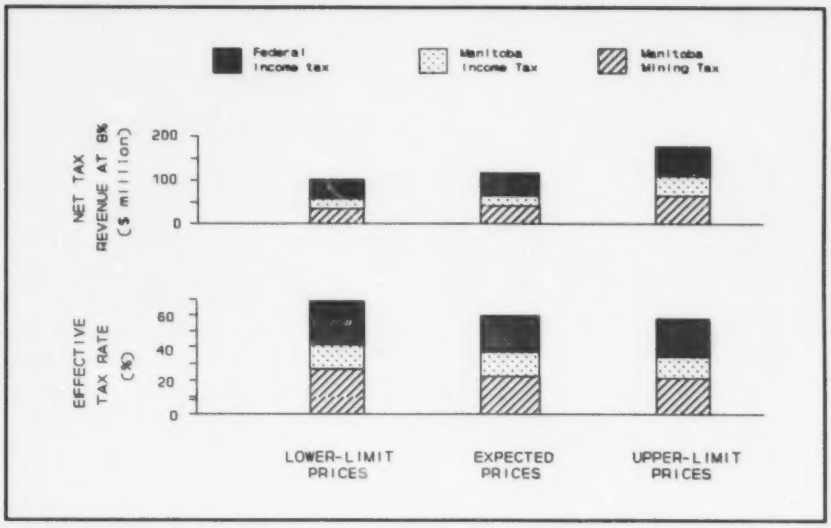


Figure 33. Taxation criteria from the start of development as a function of metal price



Summing Up

The mining taxation system in Manitoba is shown to have a very negative impact on the incentive to invest in mineral exploration and mine development. The system also is quite inefficient. A significant number of potentially economic deposits are rendered uneconomic on an after-tax basis. While investment in mineral exploration remains uneconomic at lower-limit prices, a positive investment incentive still prevails at expected and upper-limit price levels.

The effective long-term tax rate in Manitoba is typically in the order of 55 percent, made up of

- a federal income tax rate of 20 percent;
- a Manitoba income tax rate of 11 percent;
- a Manitoba mining tax rate of 24 percent.

The Manitoba government is found to collect about 65 percent of the tax revenues, with the federal government receiving the remaining 35 percent.

7. Manitoba's Competitive Tax Position in Canada

Introduction

The effects of taxation in Manitoba are now compared with those which characterize other Canadian provinces and territories. For this purpose, the 1991 tax system in each jurisdiction (outlined in Appendix VII) is applied in turn to Manitoba's before-tax mining potential.

The interprovincial comparisons which follow are mainly presented in terms of *comparative tax levels*. As previously discussed, the average discounted tax payments for an economic deposit are in each case measured in relation to those which would be collected in Manitoba with the 1991 taxation regime (assigned an index of 100). A comprehensive set of results for the after-tax cash flow characteristics and expected values for an economic deposit, and the associated mining taxation criteria, can be found in Appendix IX.

Interprovincial Comparison from the Start of Exploration[28]

[28] Tables 24 and 25, Appendix IX.

The comparative level of taxation in Manitoba relative to the ten other provinces and territories, measured from the start of exploration, is illustrated in Figure 34. The overall incidence of taxation in Manitoba is shown to be significantly higher than in all other jurisdictions with the exception of British Columbia. Relative to the index of 100 for Manitoba, comparative tax levels vary from 75 in Québec and the Northwest Territories to 101 in British Columbia. With respect to other players in the Shield region, the Ontario tax system gives an index of 80, and Saskatchewan stands at 87.

Manitoba's competitive tax position with respect to each of the three components which make up this composite picture is now examined. Comparative federal corporate income tax levels are shown in Figure 35. Federal tax payments are of a similar order for all jurisdictions with the exception of the three maritime provinces where the investment tax credit is still operative, giving a notable degree of relief.[29]

[29] Variation in the number of deposits which would be economic on an after-tax basis gives rise to the other interprovincial differences. The number of economic deposits varies from 19 in Manitoba to 22 in Nova Scotia, Québec, Alberta, Yukon, and the Northwest Territories.

Figure 36 presents the comparative provincial and territorial corporate income tax levels. Manitoba tax payments are substantially less than in British Columbia, somewhat lower than in the maritime provinces, the same as those which would be collected in Alberta, and significantly higher than in the other jurisdictions, particularly Québec, Yukon, and the Northwest Territories.

Levels of provincial mining tax and royalty are compared in Figure 37. The incidence of taxation in Manitoba stands out as being much higher than in the other Canadian jurisdictions. Comparative tax levels range from 45 in Nova Scotia and Alberta, to 89 in Newfoundland. Elsewhere in the Shield region, Québec stands at 59, the Ontario mining tax system achieves an index of 48, and Saskatchewan an index of 62.

Figure 34. Manitoba's competitive position: interprovincial comparison of total tax payments from the start of exploration

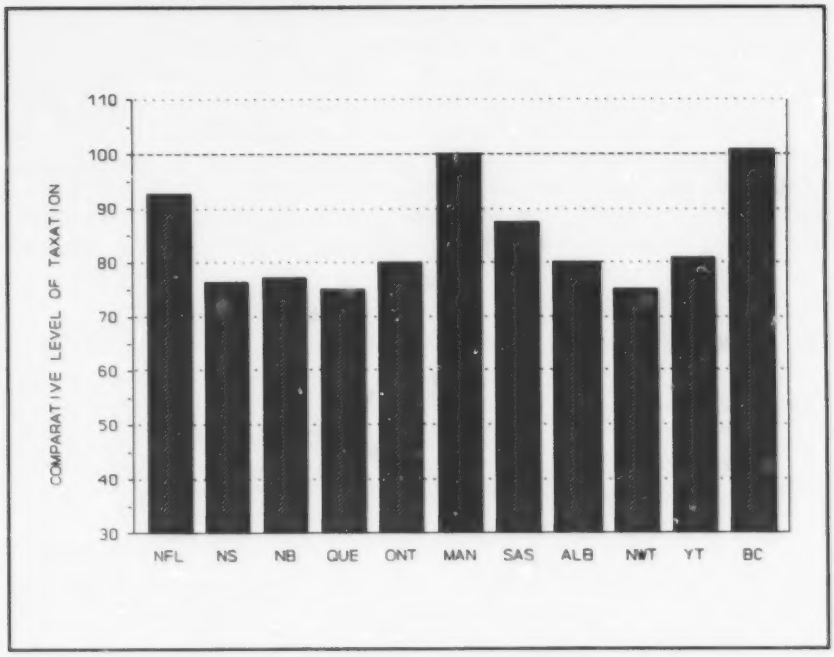


Figure 35. Manitoba's competitive position: interprovincial comparison of federal income tax payments from the start of exploration

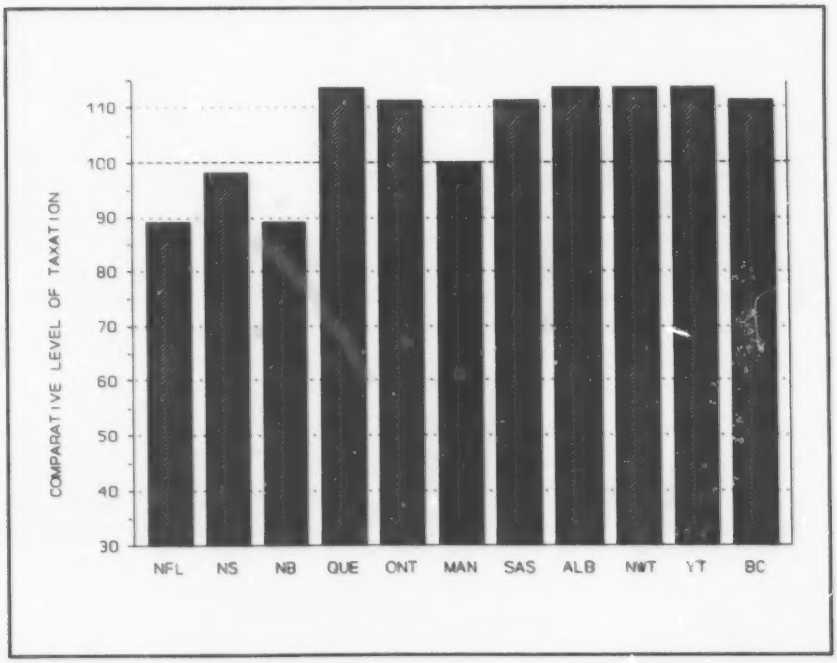


Figure 36. Manitoba's competitive position: interprovincial comparison of provincial income tax payments from the start of exploration

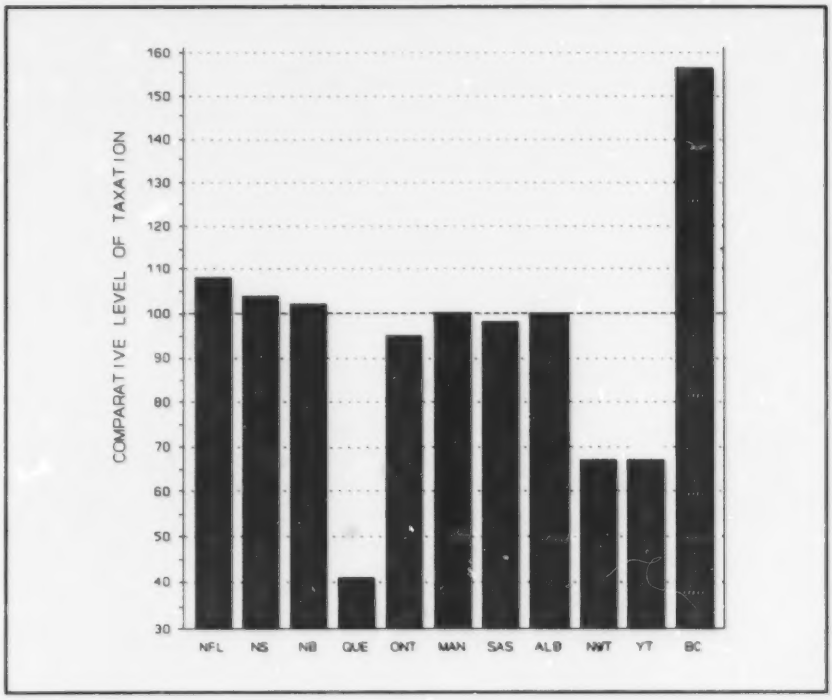
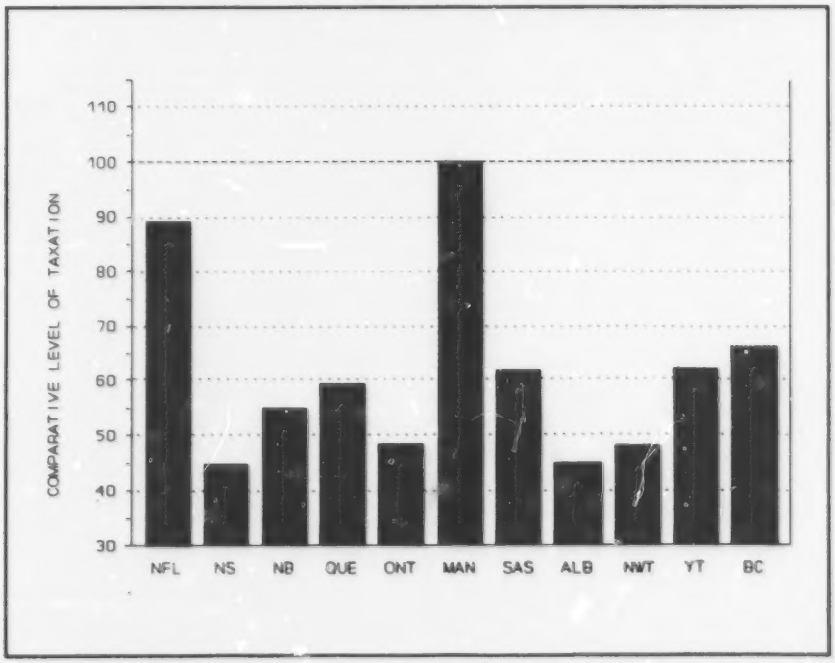


Figure 37. Manitoba's competitive position: interprovincial comparison of provincial mining tax payments from the start of exploration



[30] Tables 24 and 26, Appendix IX.

Interprovincial Comparison from the Start of Development[30]

Figure 38 presents comparative overall levels of taxation as evaluated in the medium term from the start of mine development. Manitoba's competitive tax position improves somewhat relative to New Brunswick, compared to its standing as viewed from the start of exploration. With respect to the other jurisdictions, Manitoba's competitive standing is found to deteriorate further.

More specifically, the provincial mining tax and royalty levels are compared in Figure 39. A notable improvement is evident in Manitoba's standing relative to New Brunswick, Québec, Ontario, and Nova Scotia, compared to the long-term assessment from the start of exploration. Otherwise, the competitive position of Manitoba is weaker.

[31] Tables 27-31, Appendix IX.

Interprovincial Comparison as a Function of Metal Price[31]

The sensitivity of comparative tax levels to the range of metal price conditions specified in Table 4 is examined in this section.

Interprovincial comparisons of provincial mining taxation and royalty levels, appraised from the start of exploration, are presented in Figure 40 for expected and upper-limit prices.[32] As prices are raised to the upper limit, Manitoba's competitive position with respect to New Brunswick, Nova Scotia, and Ontario improves. However, relative to the other provinces and territories, Manitoba's standing is shown to decline further.

[32] Investment in exploration at lower-limit prices is assessed to be uneconomic. Therefore, the associated tax criteria have not been calculated.

Figure 41 compares the provincial mining taxation and royalty levels from the start of mine development as a function of metal prices. The findings with respect to Manitoba's competitive position are mixed. In half the cases – Nova Scotia, New Brunswick, Ontario, Yukon, and the Northwest Territories – the province's standing improves somewhat as metal prices are raised from lower-limit to upper-limit levels. Relative to the other provincial jurisdictions, Manitoba's position either stays the same or deteriorates.

Summing Up

Manitoba's competitive tax position is examined for a wide range of conditions, relative to ten other Canadian provinces and territories. Results clearly demonstrate that the level of mining taxation in Manitoba is substantially higher than in the other jurisdictions, particularly with respect to provincial mining tax. While there is a high degree of interprovincial variation, the overall tax level in Manitoba is about 20 percent higher than elsewhere. More specifically, the level of Manitoba mining tax is in the order of 40 percent above the tax revenues which would be collected in the other Canadian jurisdictions.

There are two main reasons which explain these findings:

- allowable deductions are more restricted and nominal tax rates are higher in Manitoba than elsewhere in Canada;
- the Manitoba tax system is relatively inefficient. Of the 23 deposits which are potentially economic under base case conditions, only 19 would justify development in Manitoba on an after-tax basis. In the other jurisdictions analyzed, the number of economic deposits after tax varies from 20 to 22.

Figure 38. Manitoba's competitive position: interprovincial comparison of total tax payments from the start of development

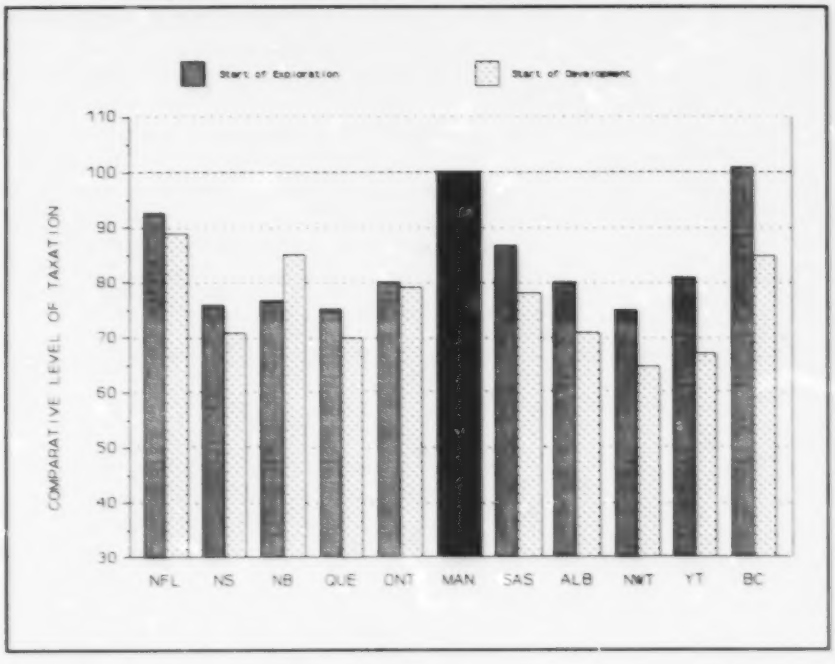


Figure 39. Manitoba's competitive position: interprovincial comparison of provincial mining tax payments from the start of development

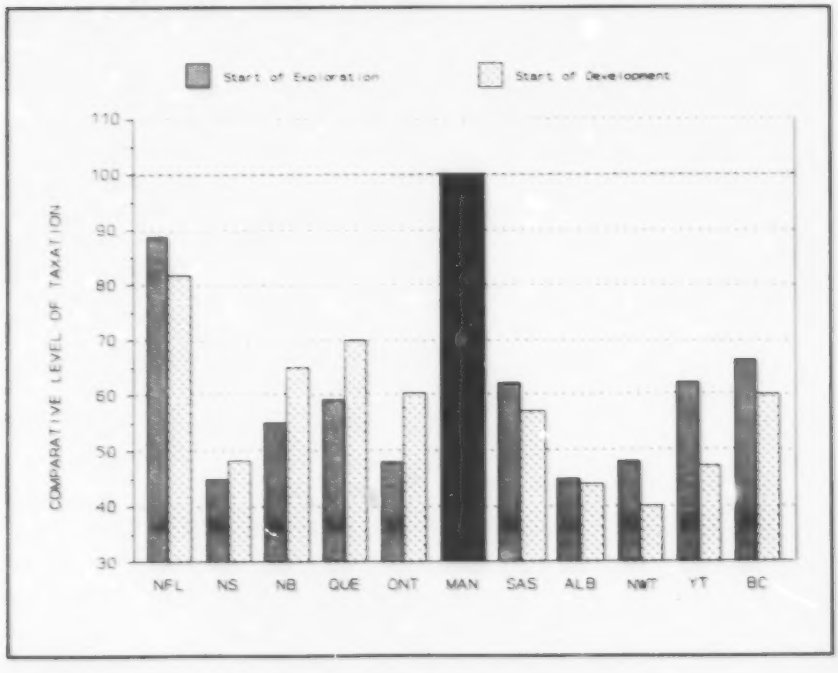


Figure 40. Manitoba's competitive position: interprovincial comparison of provincial mining tax payments from the start of exploration as a function of metal price

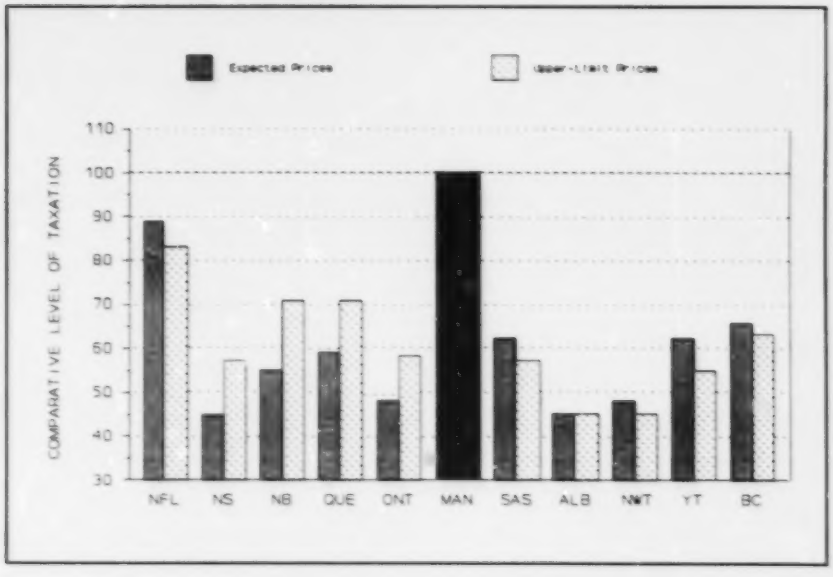
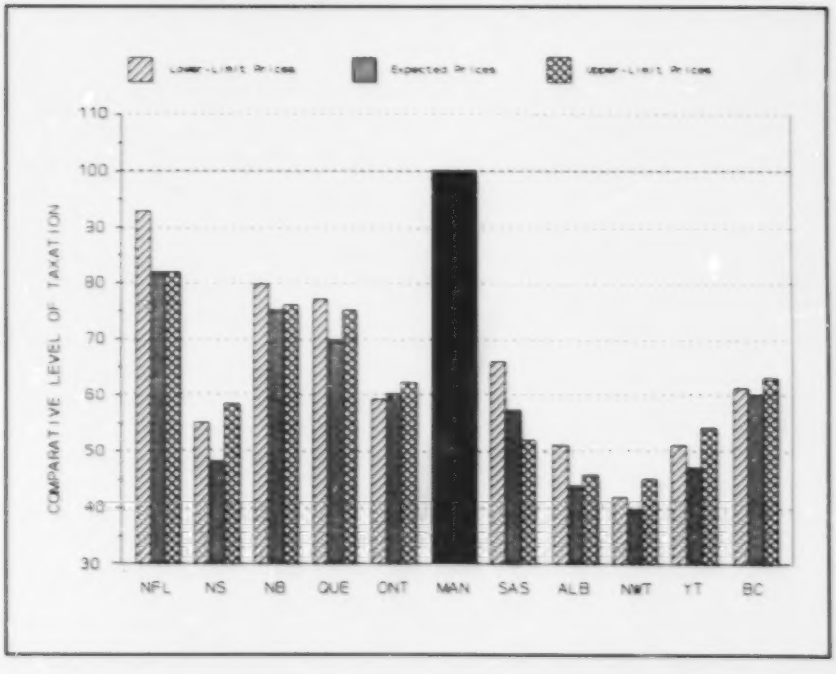


Figure 41. Manitoba's competitive position: interprovincial comparison of provincial mining tax payments from the start of development as a function of metal price



Manitoba's comparatively high level of taxation may be viewed as favourable in terms of the short-term collection of government revenue from currently operating mines. On the other hand, it places the province in an unfavourable competitive position in terms of attracting investment funds for mineral exploration and new mine development. This investment is required if the full wealth-creating potential of Manitoba's undiscovered and undeveloped mineral resources is to be realized.

8. Examination of Manitoba's Mining Tax Options

Introduction

Given Manitoba's unfavourable tax position in Canada, the purpose of this chapter is to analyze the effects of possible changes in Manitoba mining taxation policy on closing the existing competitive gap with the other provinces and territories. Six individual tax options are examined. Each represents a specific change in the current Manitoba mining tax regime.

According to the methodology applied throughout this study, two types of economic assessment are made:

- long-term appraisal of the economics of investing in mineral exploration;
- medium-term appraisal of the economics of investing in new mine development.

Following the format used in Chapter 7, the comparisons which follow are mainly presented in terms of *comparative tax levels*. The average discounted tax payments for an economic deposit are compared in each case with those which would be collected in Manitoba under the current taxation regime (assigned an index of 100).

A full set of evaluation results for the after-tax cash flow characteristics and expected values for an economic deposit, and the associated mining taxation criteria, is presented in Appendix X.

Options for Manitoba's Mining Tax

The following six individual changes in Manitoba mining taxation are considered for study purposes.

Option 1: Direct Exploration Assistance

This incentive program is designed to encourage mineral exploration by providing part of the risk capital. A government grant or tax credit of 25 percent of exploration expenditures would be provided to all individuals and companies exploring in Manitoba. The remaining 75 percent of the exploration expenses would be expensed for tax purposes.

Option 2: New-Mine Tax Holiday

This program provides for a three-year tax exemption on income from a new mine. The exempt period commences when the mine comes into production. This incentive is assumed to work in the same way as the program which operates in Ontario.

Option 3: Super Exploration Allowance

This incentive program, like option 1, is designed to stimulate mineral exploration. In this case, companies would be allowed to claim 150 percent of their exploration expenditures in Manitoba against mining income.

Option 4: Depreciation Rate of 30 Percent

This program would provide an incentive to invest in new mining and processing facilities by allowing for a faster write-off of capital expenditures. The depreciation rate would be increased from 20 percent to 30 percent per year on a declining-balance basis. This would reduce taxable income in the early years of mine life.

Option 5: Minimum Processing Allowance

Before 1988, mining companies could claim 15 percent of mining income as a minimum processing allowance for Manitoba mining tax. This incentive program would reintroduce the minimum allowance.

Option 6: Depreciation Rate of 100 Percent

This incentive program would encourage investment in new mine development by permitting all capital expenditures to be written off before taxable income is generated. In effect, the 100 percent depreciation rate would provide a tax-exempt period of variable duration for new-mine income.

Comparison from the Start of Exploration[33]

[33] Tables 32 and 33, Appendix X.

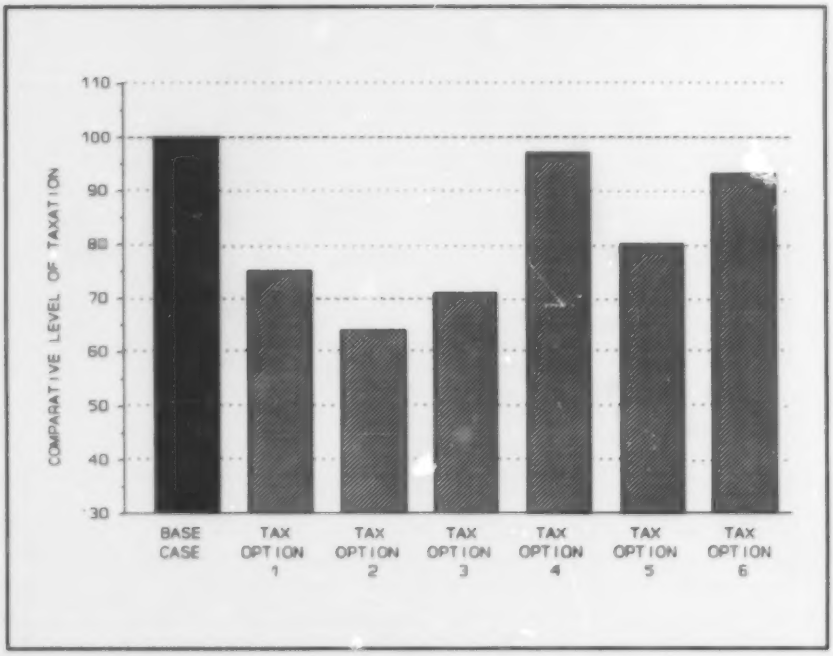
Figure 42 compares the Manitoba mining taxation levels associated with each of the six tax options relative to the taxes associated with the current system, which are given an index of 100. A notable improvement is shown in all cases, although the incentive effect varies through a wide range. The three-year tax holiday (option 2) has the strongest effect, reducing the tax level to 64. The exploration incentives (options 1 and 3) also have appreciable effects, resulting in comparative mining tax levels of 75 and 71 respectively. Reintroduction of the 15 percent minimum processing allowance (option 5) also would provide a

considerable incentive, dropping tax payments by 20 percent, compared to the government revenues which would be collected with the existing regime.[34] Increasing the depreciation rate (options 4 and 6) is shown to have the least effect, reducing the level of mining taxation by 3 percent and 7 percent respectively.[35]

[34] This incentive is of particular importance in Manitoba, where the ores from individual mineral deposits are mainly treated in large central processing facilities at Flin Flon, Snow Lake, and Thompson.

[35] Depreciation at 30 percent, compared to 20 percent declining balance (option 4), for example, results in higher allowances in the first three years following investment and lower allowances beyond the fourth year. Assuming an 8 percent cost of capital, the increase in the present value of tax credits which occurs is about 10 percent. Since Manitoba mining tax credits are equivalent to approximately 15 percent of before-tax capital expenditures, the net result of increasing the depreciation rate from a mining company viewpoint is only about a 1.5 percent reduction in after-tax capital expenditures. This explains the relatively modest improvement appraised for tax options 4 and 6. The effect would be somewhat greater if a higher discount rate were to be applied.

Figure 42. Effect of individual tax options on mining tax payments from the start of exploration



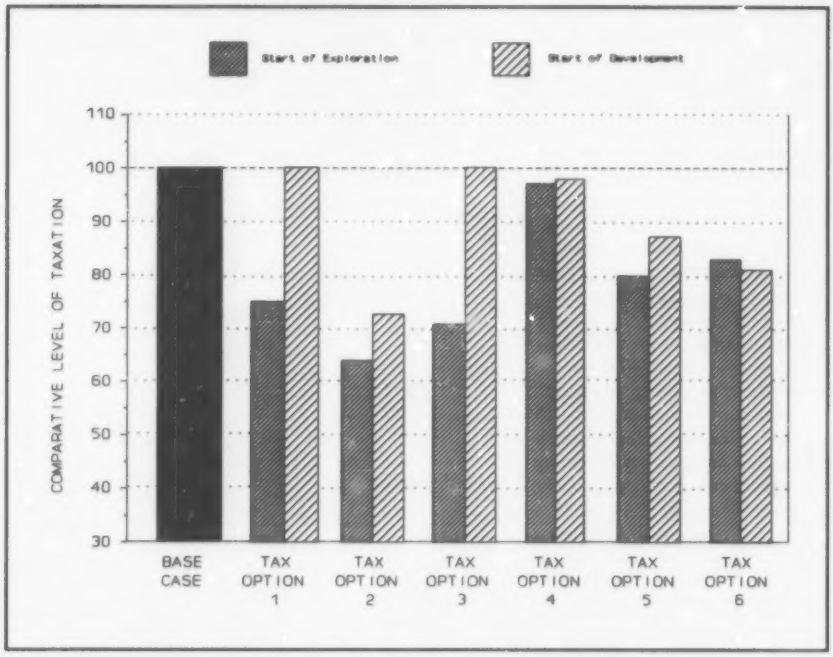
Options 2 and 6 also would improve the efficiency of taxation in Manitoba. With the three-year tax holiday and the 100 percent depreciation rate, 20 deposits would be economic on an after-tax basis. This compares with 19 deposits which would be economic in the other after-tax cases, and 23 which are economic on a before-tax basis. Thus, even incorporating the most effective provincial incentives, a considerable degree of inefficiency would remain.

Comparison from the Start of Development[36]

[36] Tables 32 and 34, Appendix X.

Comparative mining tax levels measured from the start of mine development are presented in Figure 43. The mineral exploration incentive programs (options 1 and 3) have no effect on the economics of new mine development. The incentive effects of tax options 4 and 6 are shown to be essentially the same as when their impact is measured in the long term from the start of exploration. However, a notable decrease is apparent in the incentive provided by the three-year tax holiday (option 2) and the minimum processing allowance (option 5).

Figure 43. Effect of individual tax options on mining tax payments from the start of development



Comparison as a Function of Metal Price[37]

The incentive effects of the tax options for mineral exploration as a function of metal price are illustrated in Figure 44.[38] At upper-limit prices, the two exploration incentives (options 1 and 3) have a much less pronounced effect on reducing the level of taxation. This is because the number of discoveries which would be economic at these higher prices is more than twice the number at expected prices (41 versus 19). Consequently, the average exploration expenditure per economic deposit is correspondingly lower, diminishing the impact of these options. The tax levels associated with the three-year tax holiday, and the 15-percent minimum processing allowance (options 2 and 5) show a slight increase at upper-limit prices. The incentives provided by the 30-percent depreciation rate (option 4) and the 100 percent depreciation rate (option 6) remain about the same.

Tax levels for investment in new mine development as a function of metal price are compared in Figure 45. The incentive provided by two of the tax variants which are operative in the medium term – the 30 percent depreciation rate and the 100 percent depreciation rate (options 4 and 6) – becomes weaker as metal prices rise. No systematic trend is apparent for the three-year tax holiday (option 2) or the minimum processing allowance (option 5).

[37] Tables 35-39, Appendix X.

[38] Since mineral exploration would be uneconomic at lower-limit prices, results have not been calculated.

Figure 44. **Effect of individual tax options on mining tax payments from the start of exploration, as a function of metal price**

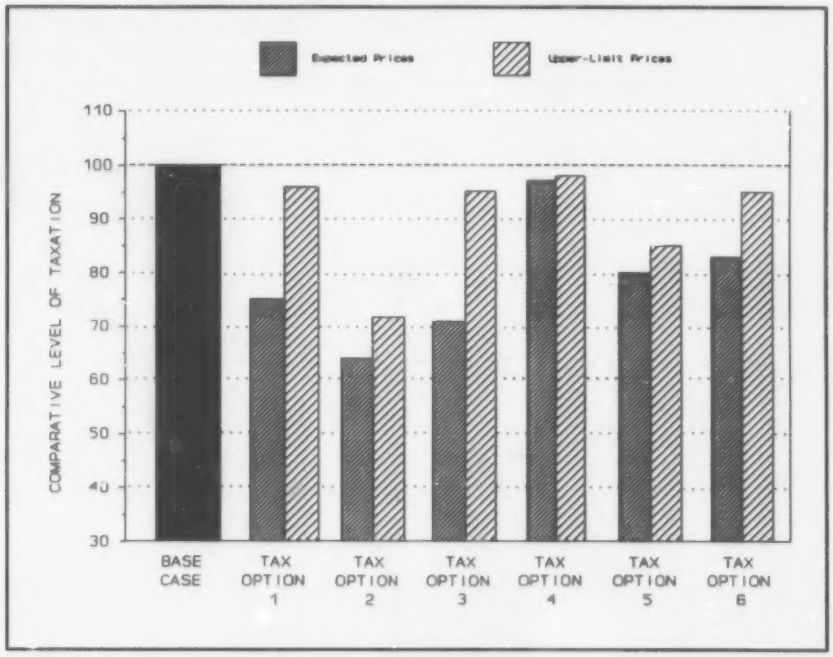
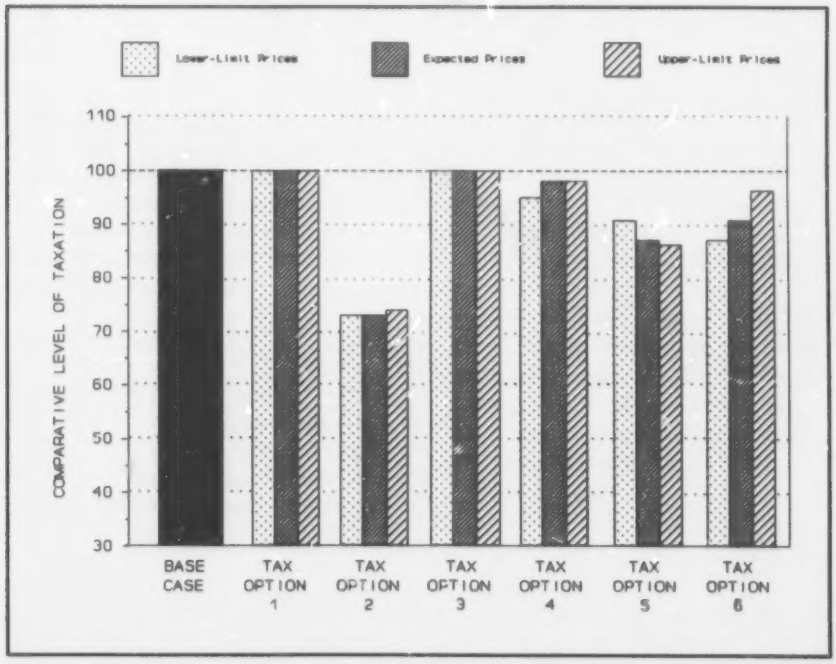


Figure 45. **Effect of individual tax options on mining tax payments from the start of development, as a function of metal price**



Effect on Manitoba's Competitive Position

The effect of the six individual tax options on the interprovincial comparison of provincial mining tax levels measured from the start of exploration is presented in Figure 46. The three-year tax holiday (option 2) and the two exploration incentives (options 1 and 3) are shown to substantially close the existing competitive gap between Manitoba and the other Canadian jurisdictions. Even with these programs in place, however, Manitoba would still stand at the high end of the interprovincial range.

Figure 46. Effect of individual tax options on Manitoba's competitive position: interprovincial comparison of mining tax payments from the start of exploration

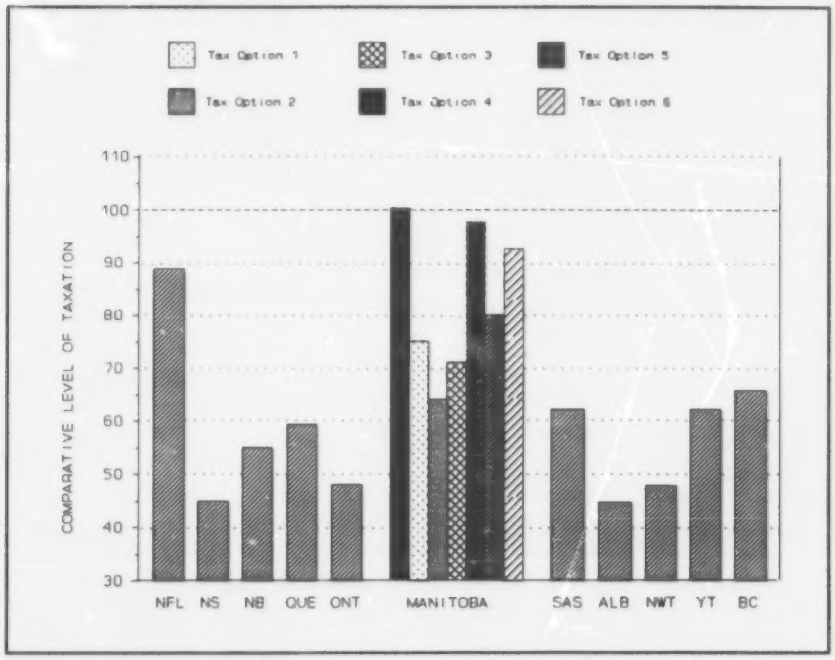
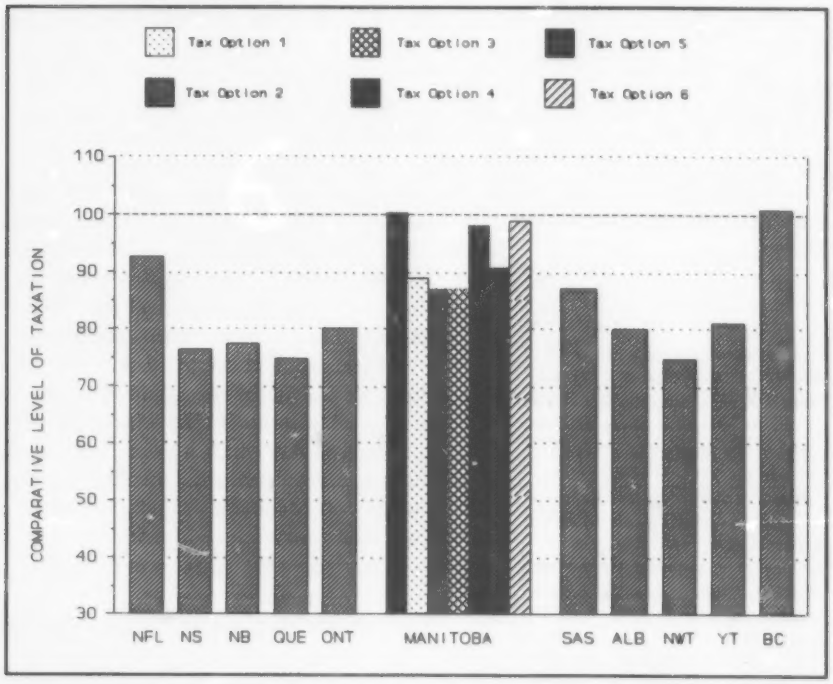


Figure 47 compares the variation in overall tax levels evaluated for Manitoba with the long-term competitive positions of the other provinces and territories. While all six tax options result in notable improvements, options 2 and 3 are once again shown to be the most effective incentives for closing the current tax gap with the rest of Canada. If either of these options were introduced in Manitoba, the overall level of taxation in the province would be about 5 percent higher than the average burden elsewhere in Canada.

Figure 47. **Effect of individual tax options on Manitoba's competitive position: interprovincial comparison of total tax payments from the start of exploration**



Summing Up

With the goal of improving Manitoba's competitive tax standing in Canada to encourage investment in mineral exploration and mine development, six individual tax options are examined. Of these, the three-year tax holiday would provide the greatest incentive, reducing the level of provincial mining taxation by about 36 percent, and the overall tax burden in Manitoba by about 13 percent. However, with this incentive in place, Manitoba would still stand at the high end of the interprovincial range of tax levels.

The incentive programs examined here offer a wide spectrum of choice in terms of policy efficiency, the incentive for investment in exploration and mine development, and the collection of government revenue. Easing the burden of taxation would no doubt stimulate growth of the province's future mining tax base. The critical issue which remains for the decision-makers is how best to balance short-term Manitoba needs and longer-term Manitoba opportunities.

9. Proposed Amendments to Manitoba's Mining Tax

Introduction

Chapters 6-8 have examined the after-tax incentive to mining companies interested in investing in mineral exploration and mine development in Manitoba. Interprovincial analysis shows Manitoba to have substantially higher mining tax levels than all other Canadian jurisdictions. Recognizing this fact, the joint industry/government tax committee of the Task Force on Mining in Manitoba began to consider changes that would improve Manitoba's competitive standing. Tax options 1-6 in Chapter 8 partially reflect the changes that were considered by this committee. In the March 1992 Manitoba Budget, the provincial government introduced proposed amendments to the Manitoba Mining Tax Act which it hopes will stimulate investment in mineral exploration and mine development. This chapter examines the effects of the proposed changes on Manitoba's mining tax levels and competitive position among Canadian provinces and territories.

Proposed Mining Taxation Changes

Two major changes to Manitoba's mining tax were proposed in the March 1992 budget:

- a mining tax holiday for new mines;[39]
- a 150 percent deduction of exploration expenditures.[40]

This incentive package represents a combination of all or parts of three individual options examined in Chapter 8. The mining tax holiday incorporates parts of the three-year tax exempt period (option 2) and the depreciation rate of 100 percent (option 6). The 150 percent deduction of exploration expenditures is similar to the super exploration allowance (option 3).

Comparison from the Start of Exploration[41]

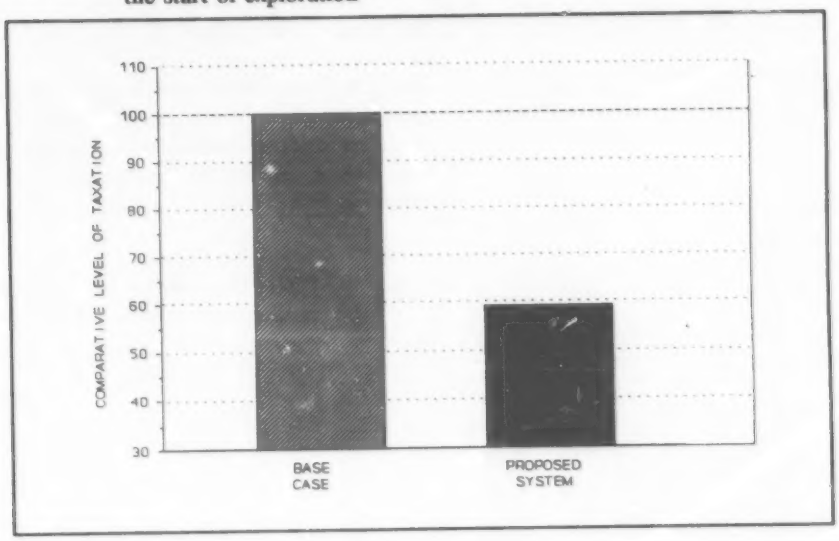
As in previous chapters, Manitoba mining taxation levels associated with the current system are given an index of 100. Figure 48 shows that the proposed mining tax system would provide a large incentive, decreasing mining tax payments by 41 percent relative to the current system.

[39] The tax holiday effectively means that new mine operators will not be subject to Manitoba mining tax until profits for mining tax purposes are equal to the preproduction capital costs of the mine. The new mine operator will then be able to utilize the undepreciated balance of assets available at the end of the tax holiday. This potential for the use of residual depreciation provides an extra incentive beyond that of a 100 percent depreciation rate. Basing the tax holiday on the amount of preproduction capital expenditures was considered to be a fairer policy than that of a fixed period, which has perhaps greater potential for abuse.

[40] Because one of the objectives of the proposed amendments is to increase exploration expenditures, the exploration incentive of 150 percent would only apply to incremental exploration expenditures exceeding a company's average for the previous three years' expenditures in Manitoba. A company exploring in Manitoba for the first time would receive the 150 percent credit for the first year's expenditures since it would be working from a "zero" base. This condition is assumed in the following analysis.

[41] Tables 40 and 41, Appendix XI.

Figure 48. Effect of proposed tax amendments on mining tax payments from the start of exploration

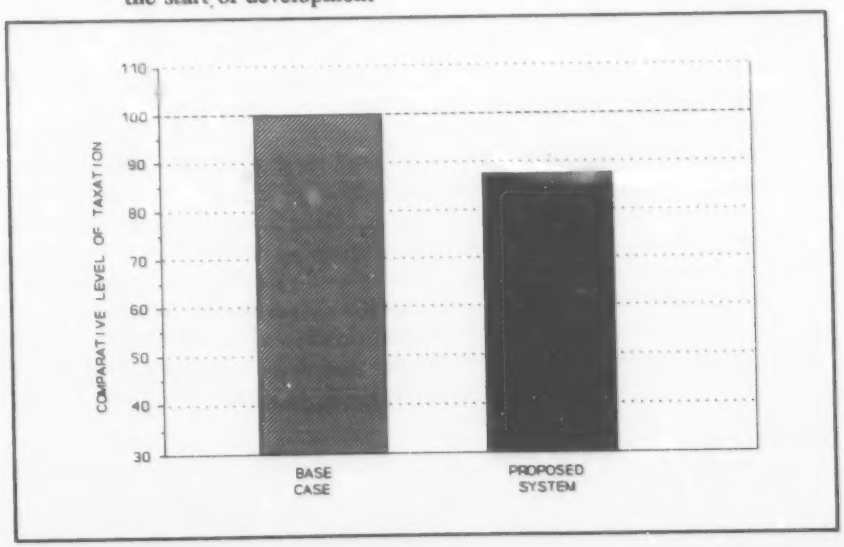


Comparison from the Start of Development[42]

[42] Tables 40 and 42, Appendix XI.

Comparative mining tax levels from the start of mine development are presented in Figure 49. The mineral exploration incentive portion of the proposed changes has no effect on the economics of new mine development. As a result, the overall incentive is not as strong as from the start of exploration. Nonetheless, the tax payments drop to 87 percent of those under the current system.

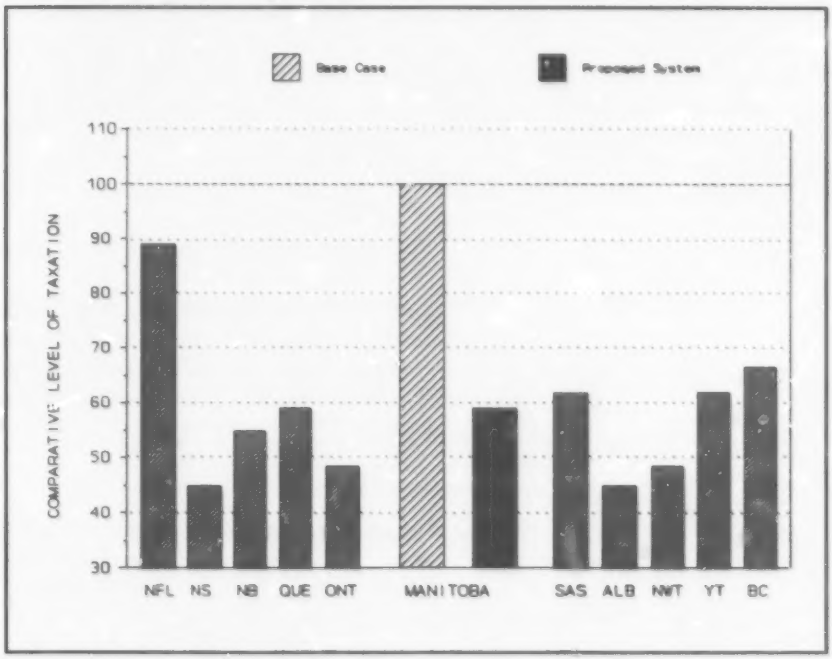
Figure 49. Effect of proposed tax amendments on mining tax payments from the start of development



Effect on Manitoba's Competitive Position

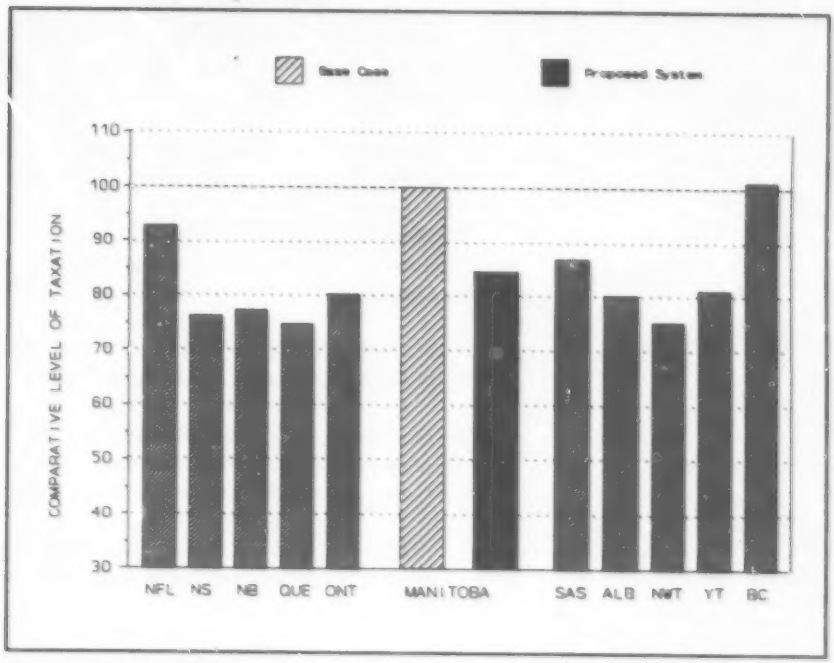
The impact of the proposed amendments to Manitoba's mining tax on its long-term competitive position with respect to provincial mining tax payments is shown in Figure 50. These proposed changes go a long way toward closing the current tax gap with the rest of Canada. Under the new system, tax payments would be lower in Manitoba than in four provinces (Newfoundland, Saskatchewan, Yukon, and British Columbia), equal to Québec's, and higher than in the remaining five provinces.

Figure 50. Effect of proposed tax amendments on Manitoba's competitive position: interprovincial comparison of mining tax payments from the start of exploration



With respect to total tax payments, Figure 51 illustrates Manitoba's competitive position in league with the other Canadian provinces and territories. Once again, the proposed tax changes in Manitoba result in tax payments being brought into line with those in the other jurisdictions. At 84 percent of the total tax payments reflected under the current system, the proposed system would result in less total tax paid than in Newfoundland, Saskatchewan and British Columbia. Although tax payments would still be higher than in the remaining seven jurisdictions, the difference would be substantially reduced.

Figure 51. Effect of proposed tax amendments on Manitoba's competitive position: interprovincial comparison of total tax payments from the start of exploration



Summing Up

Recognizing that future investment in mineral exploration and mine development hinges on making Manitoba's mining tax system more competitive, the March 1992 Manitoba Budget proposed amendments to the Manitoba Mining Tax Act. The changes amount to an incentive package incorporating parts of three of the individual options examined earlier in this study. This package has the effect of reducing the long-term level of provincial mining tax by about 41 percent and the overall tax burden for mining in Manitoba by about 16 percent.

The proposed changes also significantly enhance Manitoba's competitive tax position relative to other Canadian jurisdictions. Mining tax payments would represent 59 percent of those under the current system. This value is roughly equal to the average value (58 percent) across the other ten Canadian jurisdictions.

The individual tax options outlined in the previous chapter provided the basis for examining possible directions for taxation policy in Manitoba. These results have played a very useful role in the formulation of mining tax amendments as outlined in the March 1992 Manitoba Budget. In turn, these proposed changes greatly enhance Manitoba's competitive position and the potential for wealth creation in the Manitoba mineral sector.

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APPENDICES

Appendix I

Inflation Multiplier Series Used in Study

Year	GDP Implicit Price Index (1986 = 100)	Change From Previous Year (percent)	Inflation Multiplier (1990 = 1.000)
1946	13.9		8.533
1947	15.2	9.9	7.762
1948	17.2	12.8	6.883
1949	17.9	4.2	6.603
1950	18.3	2.3	6.457
1951	20.4	11.5	5.790
1952	21.2	4.0	5.569
1953	21.2	0.0	5.569
1954	21.6	1.5	5.486
1955	21.7	0.8	5.445
1956	22.5	3.7	5.249
1957	23.0	2.2	5.138
1958	23.3	1.4	5.067
1959	23.8	2.1	4.963
1960	24.1	1.0	4.913
1961	24.2	0.7	4.880
1962	24.6	1.3	4.816
1963	25.1	2.0	4.722
1964	25.7	2.6	4.603
1965	26.5	3.5	4.464
1966	27.8	4.9	4.255
1967	29.0	4.1	4.079
1968	30.0	3.6	3.943
1969	31.4	4.6	3.768
1970	32.8	4.6	3.607
1971	33.9	3.2	3.490
1972	35.8	5.7	3.304
1973	39.0	8.8	3.033
1974	44.6	14.3	2.652
1975	49.0	10.0	2.414
1976	53.3	8.6	2.220
1977	56.6	6.2	2.090
1978	60.0	6.2	1.972
1979	66.0	10.0	1.792
1980	73.0	10.5	1.621
1981	80.9	10.9	1.462
1982	87.9	8.7	1.346
1983	92.3	5.0	1.282
1984	95.2	3.1	1.243
1985	97.7	2.6	1.211
1986	100.0	2.4	1.183

Year	GDP Implicit Price Index (1986 = 100)	Change From Previous Year (percent)	Inflation Multiplier (1990 = 1.000)
1987	104.7	4.8	1.130
1988	109.7	4.9	1.078
1989	114.9	4.8	1.030
1990	118.3	3.0	1.000

Note: The inflation multiplier, derived from the Gross Domestic Product (GDP) Implicit Price Index, is used to convert historical current-dollar statistics to 1990-dollar equivalents.

Sources:

1946: estimated from the relationship with the consumer price index (CPI) for the 1947-51 period as follows:
- average (GDP/CPI) for 1947-51 = 0.90;
- CPI for 1946 = 19.0;
- estimated GDP index for 1946 = 19.0 (.90) = 17.1

1947-90: prepared by Karen Wilson, Income and Expenditure Accounts Division, Statistics Canada

Appendix II

Exploration Expenditure Estimates

Total Mineral Exploration

Mineral exploration expenditures are based on data collected from mining and exploration companies by Statistics Canada (STCAN), by its predecessor Dominion Bureau of Statistics (DBS), and by the federal Department of Energy, Mines and Resources (EMR). These data are grouped by province and territory and, until 1963, by commodity group. From 1963-1984, it is necessary to break out proportions of the provincial expenditure totals to represent individual commodities. Since 1984 these breakdowns have been published by EMR. Exploration expenditures for four commodity groups are pertinent to this study: total metallic minerals; base metals (copper, lead, zinc, molybdenum); gold; and nickel. In order to derive these series, it is necessary to deduct first non-metallic exploration expenditures and then non-study metallic mineral expenditures from STCAN provincial totals.

Metallic Mineral Exploration

Total metallic mineral exploration expenditures for Manitoba are shown in Table 8. Values for the 1946-67 period are based on DBS figures for total exploration by metal mining companies. The DBS breakdown by commodity grouping reveals lower values for certain metals than those indicated from other sources. In these cases, the annual totals have been increased to reflect the higher values. For example, the expenditures for nickel exploration are not fully covered by DBS in the early 1950s. More complete provincial government and industry statistics have been used to represent these values. As a result, the provincial total for metallic mineral exploration has been proportionately increased.

For the 1968-88 period, total metallic exploration expenditures in Manitoba are based on STCAN and EMR values for total on-property and off-property expenditures, less any non-metal exploration expenditures. As well, gold exploration expenditures on known deposits have been deducted (see below).

Exploration for Non-Study Metals

In order to derive exploration expenditure series for the commodities examined in this study (base metals, gold and nickel), expenditures for non-study metals must be deducted from total metallic mineral exploration expenditures as described above. The non-study metals comprise three commodity groupings: uranium, iron ore, and "others".

Uranium exploration expenditure estimates for the period 1946-65 are based on a synthesis of published estimates, data obtained from a number of provincial and federal government sources, and subjective estimates by exploration personnel. From 1975-85, estimates reflect published figures from provincial governments, as well as values obtained through surveys of the uranium industry by URAG.

It is difficult to obtain reliable information on iron ore exploration expenditures over the study period. Subjective estimates based on provincial and federal government reports form the basis of the iron ore series in the early years of the study. From 1975-85, data are more complete because of better figures from provincial governments and the beginning of detailed commodity breakdowns for exploration expenditures by EMR.

"Other" metals include tin, tungsten, chromite, niobium, platinum group and other less important metals. Exploration expenditures for this category are small in most years and are based on subjective estimates from a combination of provincial and federal government and mining company sources.

Generally, the non-study metals do not constitute a large portion of overall exploration expenditure in Manitoba. The three study commodity groupings account for approximately 95 percent of total metallic mineral exploration expenditure during the study period.

Gold Exploration

Deducting the exploration expenditures for non-study metals from those for total metallic minerals leaves the values for base metals, gold and nickel. To further the commodity breakdown, gold exploration expenditures have been separated as shown in Table 8.

From 1946-63, only exploration by gold mining companies was classified by DBS as gold exploration. Other companies were considered not to have explored for gold, and gold mining companies were assumed to have looked only for gold. While this was not strictly the case, we assume that exploration by gold mining companies for other metals was offset by exploration expenditures of other companies searching for gold.

Estimates for gold exploration from 1964-74 are based on subjective estimates of federal and provincial governments and exploration personnel.

From 1975, the Statistics Canada questionnaire sent to exploration and mining companies asked for breakdowns of exploration expenditures by commodity and province. Estimates of total gold expenditures in each province are based on totals obtained when individual company expenditures for gold are totalled. This is done for the years 1975, 1977, 1979, 1981, 1983, and 1985. Values for years in which disaggregated data are missing during the 1975-85 interval are estimated by interpolating between the values for adjacent years.

For 1986-88, values have been obtained from the EMR questionnaire on mineral exploration. Gold is assumed to represent 100 percent of the total precious metal exploration expenditure.

Due to large increases in gold price in the late 1970s and early 1980s, many companies began to re-explore known gold deposits and old gold producers. Examples of these deposits in Manitoba would include San Antonio and Nor Acme. Since no new discoveries result from this exploration, the related expenditures should not be included in the total for gold exploration.

As a result, estimates for gold exploration expenditures in Manitoba from 1980-88 represent the total STCAN/EMR values as described above, less estimates for expenditure on known deposits and ex-producers. In some years, this procedure results in a reduction of more than 50 percent in the gold exploration expenditure as reported by STCAN/EMR.

Nickel

Exploration expenditure estimates for nickel are shown in Table 8. Values for nickel exploration expenditures for the period 1946-50 are contained in DBS data for nickel-copper mines. From 1951-88, estimates are based on data provided by Inco, Falconbridge, Hudson Bay Mining and Smelting and the Manitoba Department of Energy and Mines.

Base Metal Expenditure

The process of deducting exploration expenditures for all other metals from the value for total metallic mineral exploration expenditures has left a residual which represents expenditures for base metal exploration. For the purposes of this study, the base metals group comprises copper, lead, zinc and molybdenum. Base metal exploration expenditures for Manitoba during the 1946-88 period are shown in Table 8.

From 1985-88, base metal exploration expenditures have been derived by deducting estimates for nickel exploration from the value for "base metal" exploration reported by EMR.

Constant Dollar Exploration Expenditures

To examine real constant dollar trends in exploration expenditures, inflationary effects have to be removed from the current dollar series presented in Table 8. Since the purchasing power of a dollar is assumed to remain constant, some year (1990 in this case) is specified to define the constant money base. The current dollar expenditures are converted to constant 1990 dollars using the inflation multiplier series derived from the Gross Domestic Product (GDP) Implicit Price Index for Canada in Appendix I.

Table 9 shows total metallic mineral, base metal, gold and nickel expenditures in Manitoba in constant 1990 dollars. These estimates are used for study purposes as summarized in Table 1 in the text.

Table 8. Exploration expenditures in Manitoba ($ current, thousands)

Year	Total Metallic Minerals	Base Metals	Gold	Nickel	Total Study Minerals
1946	815	490	299	26	815
1947	1,294	78	425	791	1,294
1948	941	251	94	596	941
1949	495	141	56	298	495
1950	323	86	48	189	323
1951	657	55	31	571	657
1952	919	5	63	851	919
1953	2,260	49	75	2,136	2,260
1954	1,995	122	24	1,842	1,988
1955	2,374	188	24	2,130	2,342
1956	9,369	2,246	91	6,789	9,126
1957	10,534	4,040	176	6,163	10,379
1958	12,286	3,020	111	9,052	12,183
1959	7,826	2,404	127	5,264	7,795
1960	8,108	2,661	248	5,171	8,080
1961	7,109	2,637	615	3,813	7,065
1962	5,375	1,745	119	3,309	5,173
1963	4,693	1,649	1	3,016	4,666
1964	3,900	129	109	3,272	3,510
1965	6,100	908	138	4,444	5,490
1966	6,500	1,643	195	4,012	5,850
1967	6,337	1,494	191	4,018	5,703
1968	8,330	3,456	250	3,791	7,497
1969	11,172	4,221	335	5,499	10,055
1970	14,112	5,350	705	7,351	13,406
1971	13,230	5,112	662	6,794	12,568
1972	5,978	1,536	299	3,844	5,679
1973	6,762	3,574	338	2,512	6,424
1974	8,330	4,363	416	3,084	7,863
1975	7,056	3,403	353	2,897	6,653
1976	6,664	2,300	999	2,711	6,010
1977	9,212	4,188	1,382	2,767	8,337
1978	12,544	4,987	1,882	4,839	11,708
1979	14,308	9,012	2,146	3,789	14,947
1980	25,609	16,119	4,087	3,248	23,454
1981	23,040	17,380	776	2,928	21,084
1982	16,820	9,875	4,716	939	15,530
1983	11,109	5,102	4,112	1,134	10,348
1984	20,248	6,530	10,589	1,115	18,234
1985	35,127	14,307	15,877	2,927	33,111
1986	25,172	3,817	14,921	4,328	23,066
1987	38,538	10,367	21,378	4,043	35,788
1988	29,825	11,056	12,858	3,380	27,294

Table 9. Exploration expenditures in Manitoba ($ 1990, thousands)

Year	Total Metallic Minerals	Base Metals	Gold	Nickel	Total Study Minerals
1946	6,955	4,181	2,551	222	6,955
1947	10,042	604	3,299	6,139	10,042
1948	6,478	1,729	647	4,102	6,478
1949	3,265	928	370	1,968	3,265
1950	2,088	557	310	1,220	2,088
1951	3,803	317	180	3,306	3,803
1952	5,116	25	351	4,740	5,116
1953	12,586	272	418	11,896	12,586
1954	10,944	671	132	10,105	10,907
1955	12,926	1,024	131	11,597	12,752
1956	49,177	11,789	478	35,635	47,902
1957	54,123	20,757	904	31,665	53,327
1958	62,249	15,302	562	45,863	61,728
1959	38,842	11,934	630	26,126	38,691
1960	39,835	13,073	1,218	25,406	39,697
1961	34,694	12,870	3,001	18,608	34,479
1962	25,885	8,402	573	15,935	24,911
1963	22,162	7,789	5	14,242	22,036
1964	17,952	594	502	15,061	16,157
1965	27,231	4,053	616	19,839	24,508
1966	27,660	6,992	830	17,073	24,894
1967	25,851	6,094	779	16,391	23,264
1968	32,848	13,628	986	14,949	29,563
1969	42,091	15,903	1,262	20,718	37,882
1970	50,898	19,296	2,543	26,513	48,352
1971	46,168	17,839	2,310	23,709	43,858
1972	19,754	5,076	988	12,702	18,766
1973	20,511	10,841	1,025	7,620	19,846
1974	22,095	11,573	1,103	8,180	20,856
1975	17,035	8,217	852	6,994	16,063
1976	14,791	5,105	2,217	6,017	13,340
1977	19,254	8,754	2,889	5,783	17,426
1978	24,733	9,832	3,711	9,541	23,084
1979	25,646	16,153	3,847	6,791	26,791
1980	41,501	26,121	6,623	5,264	38,008
1981	33,691	25,414	1,135	4,282	30,831
1982	22,637	13,291	6,347	1,264	20,901
1983	14,238	6,539	5,270	1,453	13,263
1984	25,161	8,115	13,158	1,386	22,659
1985	42,534	17,324	19,225	3,544	40,092
1986	29,778	4,516	17,652	5,120	27,287
1987	43,544	11,714	24,155	4,568	40,437
1988	32,163	11,923	13,866	3,645	29,434
1946-69	546,133	237,642	128,916	144,376	510,934
1970-88	574,801	159,489	20,734	372,807	553,030
1946-88	1,120,934	397,131	149,650	517,583	1,063,963

Appendix III

Possible Economic Discoveries for Evaluation

Name	Discovery Date	Name	Discovery Date
Base Metal Deposits			
Anderson	1963	Osborne Lake	1953
Bur	1984	Pen II	1986
Callinan	1984	Pinebay	1961
Centennial	1969	Rail Lake	1967
Chisel Lake	1956	Reed Lake	1969
Chisel North	1987	Rod	1968
Farewell Lake	1974	Ruttan	1969
FL-DH	1951	Ruttan West	1988
Fox	1961	Schist Lake	1947
Frances Lake	1977	Spruce Point	1973
Ghost Lake	1956	Stall	1956
Jungle	1958	Sylvia	1977
Lost Lake	1974	Trout Lake	1976
MacBride Lake	1971	Westarm	1973
Morgan Lake	1984	White Lake	1963
North Star	1950	Wim	1968
Gold Deposits			
Burnt Timber	1984	Margaret Extension	1987
Farley Lake	1986	Puffy Lake	1981
Little Stull	1986	Tartan Lake	1984
MacLelland	1965		
Nickel Deposits			
Birchtree	1962	Pipe 1	1957
Bucko Lake	1961	Pipe 2	1958
Lynn Lake	1946	Setting Bay	1979
Manibridge	1963	Soab North	1953
Maskwa West	1974	Soab South	1958
Minago	1969	South Mystery	1949
Moak	1952	Thompson 1D	1969
Namew Lake	1984	Thompson Main	1956
Ospwagen	1975		

Appendix IV

Other Discoveries Considered but Excluded from the Evaluation

Name	Discovery Date	Reason for Exclusion
Base Metal Deposits		
Barrington Lake	1970	Too Small
Bob	1941	Pre-1946 Discovery
Copperman	1928	Pre-1946 Discovery
Cuprus	1938	Pre-1946 Discovery
Dickstone	1936	Pre-1946 Discovery
Don Jon	1950s	Too Small
Flin Flon	1916	Pre-1946 Discovery
Goodenough	1952	Too Small
Hyers Island	1943	Pre-1946 Discovery
IT Group	1960s	Insufficient Information
Joannie	1956	Insufficient Information
Linda-McKayseff	*	Insufficient Information
Mandy	1915	Too Small
Norris Lake	1980	Too Low-Quality
Pot Lake	1956	Too Small
Sherridan	1926	Pre-1946 Discovery
Vamp Lake	1928	Pre-1946 Discovery
West Frances	1976	Too Low-Quality
Z Deposit	1947	Too Small
Gold Deposits		
Albert's Lake (Wally)	1985	Too Small
Apex	1918	Pre-1946 Discovery
Big Island Lake	1987	Insufficient Information
Bon	1927	Pre-1946 Discovery
Bonanza	1986	Insufficient Information
Central Manitoba Gold	1924	Pre-1946 Discovery
Cryderman	1927	Pre-1946 Discovery
Dot	1983	Insufficient Information
Eva	1921	Pre-1946 Discovery
Ferguson Mine	1928	Pre-1946 Discovery
Ferro Mine	1930	Pre-1946 Discovery
God's Lake	pre-1946	Pre-1946 Discovery
Gold Lake	1935	Pre-1946 Discovery
Goldrock	1930	Pre-1946 Discovery
Gunnar Mine	1933	Pre-1946 Discovery
Gurney	pre-1946	Pre-1946 Discovery
Honeysuckle	1939	Pre-1946 Discovery
Island Lake	pre-1946	Pre-1946 Discovery

* discovery date unknown

Name	Discovery Date	Reason for Exclusion
Jeep	1947	Too Small
Jowsey Island	1932	Pre-1946 Discovery
Laguna	1915	Pre-1946 Discovery
Lasthope (Smoke)	pre-1946	Pre-1946 Discovery
Lotus	1920	Pre-1946 Discovery
Luleo	1920	Pre-1946 Discovery
Macketta	1938	Pre-1946 Discovery
Monument Bay (Twin Lakes)	1989	Insufficient Information
Moose	1915	Pre-1946 Discovery
Nokomis Lake	1961	Too Small
Norris Lake	1946	Too Small
North Zone	1987	Too Small
Nor-Acme	pre-1946	Pre-1946 Discovery
Ogama Rockland	1941	Pre-1946 Discovery
Packsack	1935	Pre-1946 Discovery
Ranger	1914	Pre-1946 Discovery
Rita No. 1	1936	Pre-1946 Discovery
Rusty Extension	1988	Insufficient Information
San Antonio	1927	Pre-1946 Discovery
Sannorm	1934	Pre-1946 Discovery
Solo-Oro Grande	1923	Pre-1946 Discovery
Sunbeam	1928	Pre-1946 Discovery
T1A Zone	1986	Insufficient Information
Waverly	1944	Pre-1946 Discovery
Wingold	1913	Pre-1946 Discovery
Wolf	1949	Too Small
Nickel Deposits		
Airport	1970	Insufficient Information
Bowden Lake	1963	Too Low-Quality
Burntwood	1958	Insufficient Information
Dumbarton (Maskwa)	1930s	Pre-1946 Discovery
Eagle	1943	Pre-1946 Discovery
Grass River	1950s	Insufficient Information
Hambone	1958	Insufficient Information
Island Lake	1956	Insufficient Information
Kipper	1958	Insufficient Information
Linklater	1956	Too Small
Mayville	1935	Pre-1946 Discovery
Mel	1961	Insufficient Information
Nichols	1956	Insufficient Information
North Mystery	1954	Insufficient Information
Ore Fault	1955	Too Low-Quality
Resting Lake	1950s	Insufficient Information
Rice Lake	1930s	Pre-1946 Discovery
South Manasan	1966	Insufficient Information
West Mystery	1966	Insufficient Information

Appendix V

General Revenue and Cost Relationships

Smelter Return Conditions

General Formula

$$NSV = \left[\frac{(M - D)(P - r)}{100}\right] - \left[T + t_{\pm}(P - P_b)\right] + C$$

$t_{\pm}$ = treatment charge price adjustment; t_+ applicable when $P > P_b$; t_- applicable when $P < P_b$

P_b = base price for treatment charge price adjustment, $/tonne metal

Notes:

- concentrate weights expressed on dry tonne basis assuming 8 percent moisture content;
- grades of precious metals for credit expressed in grams/tonne concentrate;
- prices of precious metals for credit expressed in $/gram;
- penalties for contaminant metals are neglected.

Copper Concentrate

$$NSV = \left[\frac{(M - D)(P - 245)}{100}\right] - [125 + 0.10(P - 2600)] + C$$

Unit deduction (D): function of M

M	D
up to 30%	1.0
30-33%	1.1
33-36%	1.2
36-40%	1.3
over 40%	1.4

Refining charge (r) = 245

Treatment charge (T) = 125

Treatment charge price adjustment ($t_{\pm}$): 0.10

Base price (P_b): 2600

Credits (C):

Gold = Payment ($) − 0.20 (M)		Silver = Payment ($) − 0.02 (M)	
M	Incremental Payment %	M	Incremental Payment %
Up to 1	–	up to 30	–
1-3	90	30-200	90
3-7	94.5	200-400	91.5
7-10	96.5	400-1200	93.5
10-50	98	1200-2000	95
over 50	98.5	over 2000	96.5

Lead Concentrate

$$NSV = \left[\frac{(M - D)(P)}{100}\right] - [180 + 0.13(P - 750)] + C$$

Unit Deduction (D): the greater of .05(M) or 3

Refining charge (r) = 0

Treatment charge (T) = 180

Treatment charge price adjustment ($t_{\pm}$): 0.13

Base price (P_b): 750

Credits (C):

Gold = [0.90(M) − 1.2](P) − 0.20(M)

Silver = [M − (greater of 0.05M or 50)] (P) − 0.01(M)

Zinc Concentrate

$$NSV = \left[\frac{(M - D)(P)}{100}\right] - [200 + 0.13(P - 1300)] + C$$

Unit Deduction (D): the greater of .15(M) or 8

Refining charge (r): 0

Treatment charge (T): 200

Treatment charge price adjustment ($t_{\pm}$): 0.13

Base price (P_b): 1300

Credits (C):

$$\text{Cadmium} = \left[\frac{.60(M - 0.2)}{100}\right](P) - 22(M)$$

$$\text{Silver} = [0.80(M - 93)](P)$$

$$\text{Gold} = [0.75(M - 0.75)](P)$$

Nickel Concentrate

$$NSV = \left[\frac{.97(M)(P - 1800)}{100}\right] - 155 + C$$

Unit deduction (D): .03(M)

Refining charge (r): 1800

Treatment charge (T): 155

Treatment charge price adjustment (t_z): 0

Credits (C):

Copper	=	.92(M/100)(P) − 810(M/100)
Cobalt	=	.74(M/100)(P) − 4000(M/100)
Gold	=	.91(M)(P) − 0.90(M)
Platinum	=	.87(M)(P) − 0.90(M)
Palladium	=	.92(M)(P) − 0.90(M)

Gold Marketing Charges

1. Free Milling Gold Ores
   - charge $0.10 per gram ($3.10 per ounce) of gold content for transportation, refining, and marketing
   - pay for 98% of silver byproduct credit
2. Refractory Gold Ores
   - charge $1.45 per gram ($45 per ounce) of gold content for transportation, refining, and marketing
   - pay for 96% of silver byproduct credit

Concentrate Transportation Costs

Road:	6.7 cents per tonne-kilometre in provinces 9.0 cents per tonne-kilometre in territories 18.0 cents per tonne-kilometre in Shield region of Northwest Territories
Rail:	up to 800 kilometres, 4.0 cents per tonne-kilometre 800-1600 kilometres, 3.6 cents per tonne-kilometre 1600-2400 kilometres, 3.2 cents per tonne-kilometre over 2400 kilometres, 2.6 cents per tonne-kilometre 12.0 cents per tonne-kilometre in territories
Ocean:	Eastern Canada-Europe, $32 per tonne concentrate Eastern Canada-Japan, $52 per tonne concentrate Western Canada-Japan, $31 per tonne concentrate Western Canada-Europe, $36 per tonne concentrate within Eastern or Western Canada, $27 per tonne concentrate
Transfers:	truck and rail modes, $5 per tonne concentrate at each transfer point ship mode, $8 per tonne concentrate at each transfer point number of transfer points = (number of modes + 1)

General Deposit Costing Relationships

The generalized deposit costing relationships used in the appraisal when actual data are not available have been developed by T.A. O'Hara. The costing functions provide an order-of-magnitude (±30 percent) level of accuracy. These relationships are outlined as follows:

- mine and mill ore capacity for open pit and underground mines as a function of recoverable ore reserves;
- site preparation cost for open pit mining as a function of topography and tree growth;
- preproduction waste-stripping cost as a function of the amounts of soil and waste rock overburden to be removed;
- capital cost of open pit equipment as a function of the annual tonnage of ore and waste to be removed, optimum shovel size, optimum truck size, and drilling conditions;
- capital cost of open pit repair and maintenance facilities as a function of the annual tonnage of ore and waste to be removed;
- capital cost of shaft sinking as a function of rock conditions, mine capacity, and shaft depth;
- capital cost of hoisting plant as a function of mine capacity and hoisting distance;

- capital cost of mine compressor plant as a function of mine capacity;
- underground mine development capital cost as a function of mine capacity and average stope width;
- capital cost of underground mining equipment, maintenance facilities, and sustaining capital requirement as functions of mine capacity and average stope width;
- capital cost of mineral processing plant as a function of ore capacity, topography, tree growth, temperature conditions, hardness of ore, and ore type. Estimated by component: site clearing and mass excavation, concrete foundations and detailed excavation, primary crusher, coarse ore storage, conveying and fine crushing plant concentrator building, fine ore storage and grinding, and the processing section;
- capital cost of electric power supply as a function of mine capacity, mine location and remoteness;
- capital cost of tailings storage as a function of mine capacity, topography, site accessibility, and environmental requirements;
- capital cost of water supply as a function of mine capacity;
- working capital requirement expressed in number of months of operating cost as a function of remoteness;
- number of persons employed as a function of mining method, mine and mill capacities, and employee accommodation provided;
- typical milling recoveries, concentrate grades, and flow of metals among concentrate products, as functions of ore types;
- capital cost of mine access road as a function of topography and distance;
- capital cost of houses, permanent bunkhouse facilities, and townsite amenities as functions of the percentages of employed persons to be accommodated, and remoteness;
- capital cost of general plant services as a function of number of employees;
- project overhead costs as a function of direct project costs;
- operating labour costs for mining, milling, maintenance, and services as a function of mine and mill capacities, mine and mill methods, stope width, and employee accommodation requirements;
- operating materials costs for mining, milling, maintenance, and services as a function of mine and mill capacities, mine and mill methods, stope width, and remoteness;
- electric power operating cost as a function of capacity, location and remoteness.

These order-of-magnitude costing relationships are indexed for variations in construction and mining wage rates among the provinces and territories, and the labour and materials costs can be indexed where appropriate to allow for remoteness cost premiums.

Appendix VI

Before-Tax Cash Flow Characteristics and Expected Values for an Economic Deposit

Table 10. Results under base case conditions

Characteristic	Base Case
Total exploration expenditures ($ million)	1,064
Number of economic deposits	23
Time periods (years)	
Exploration	8
Development (maximum)	5
Production (maximum)	48
Overall time period	57
Undiscounted values ($ million)	
Revenue	1,439
Less: Exploration expenditure	46
Development capital cost	66
Production cost	671
Cash flow	656
Economic indicators – start of development	
Net present value ($ million)	165
Rate of return (percent)	33
Economic indicators – start of exploration	
Average return (R, $ million)	91
Average exploration expenditure (E, $ million)	34
Expected value (EV, $ million)	57
Expected rate of return (percent)	14

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Table 11. Time trend results at expected prices

Characteristic	Time Interval	
	1946-69	1970-88
Total exploration expenditures ($ million)	553	511
Number of economic deposits	14	9
Time periods (years)		
Exploration	7	9
Development (maximum)	5	3
Production (maximum)	47	26
Overall time period	56	36
Undiscounted values ($ million)		
Revenue	2,094	419
Less: Exploration expenditure	40	57
Development capital cost	84	38
Production cost	966	213
Cash flow	1,004	111
Economic indicators – start of development		
Net present value ($ million)	237	53
Rate of return (percent)	34	27
Economic indicators – start of exploration		
Average return (R, $ million)	143	26
Average exploration expenditure (E, $ million)	30	39
Expected value (EV, $ million)	113	– 13
Expected rate of return (percent)	18	6

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Table 12. Results as a function of metal price

Characteristic	Price Variant		
	Lower-Limit	Expected	Upper-Limit
Total exploration expenditures ($ million)	1,064	1,064	1,064
Number of economic deposits	3	23	42
Time periods (years)			
Exploration	59	8	4
Development (maximum)	3	5	5
Production (maximum)	47	48	48
Overall time period	108	57	53
Undiscounted values ($ million)			
Revenue	2,506	1,439	1,705
Less: Exploration expenditure	355	46	25
Development capital cost	102	66	69
Production cost	1,671	671	521
Cash flow	378	656	1,090
Economic indicators – start of development			
Net present value ($ million)	146	165	300
Rate of return (percent)	25	33	48
Economic indicators – start of exploration			
Average return (R, $ million)	1	91	217
Average exploration expenditure (E, $ million)	74	34	21
Expected value (EV, $ million)	– 73	57	196
Expected rate of return (percent)	1	14	27

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Table 13. Time trend results at lower-limit prices

Characteristic	Time Interval	
	1946-69	1970-88
Total exploration expenditures ($ million)	553	511
Number of economic deposits	2	1
Time periods (years)		
Exploration	46	85
Development (maximum)	3	2
Production (maximum)	47	25
Overall time period	95	112
Undiscounted values ($ million)		
Revenue	3,237	1,042
Less: Exploration expenditure	277	511
Development capital cost	125	57
Production cost	2,123	768
Cash flow	712	− 294
Economic indicators − start of development		
Net present value ($ million)	203	30
Rate of return (percent)	28	13
Economic indicators − start of exploration		
Average return (R, $ million)	6	0
Average exploration expenditure (E, $ million)	73	75
Expected value (EV, $ million)	− 67	− 75
Expected rate of return (percent)	3	− 1

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Table 14. Time trend results at upper-limit prices

Characteristic	Time Interval	
	1946-69	1970-88
Total exploration expenditures ($ million)	553	511
Number of economic deposits	26	16
Time periods (years)		
Exploration	4	5
Development (maximum)	5	5
Production (maximum)	47	27
Overall time period	53	33
Undiscounted values ($ million)		
Revenue	2,340	674
Less: Exploration expenditure	21	32
Development capital cost	74	61
Production cost	681	260
Cash flow	1,564	321
Economic indicators – start of development		
Net present value ($ million)	414	113
Rate of return (percent)	53	34
Economic indicators – start of exploration		
Average return (R, $ million)	315	75
Average exploration expenditure (E, $ million)	18	25
Expected value (EV, $ million)	297	50
Expected rate of return (percent)	34	15

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Table 15. Results as a function of annual exploration budget

Characteristic	Annual Budget Rate		
	$3 Million	$6 Million	$9 Million
Total Exploration expenditures ($ million)	1,064	1,064	1,064
Number of economic deposits	23	23	23
Time periods (years)			
Exploration	15	8	5
Development (maximum)	5	5	5
Production (maximum)	48	48	48
Overall time period	64	57	54
Undiscounted values ($ million)			
Revenue	1,439	1,439	1,439
Less: Exploration expenditure	46	46	46
Development capital cost	66	66	66
Production cost	671	671	671
Cash flow	656	656	656
Economic indicators – start of development			
Net present value ($ million)	165	165	165
Rate of return (percent)	33	33	33
Economic indicators – start of exploration			
Average return (R, $ million)	50	91	111
Average exploration expenditure (E, $ million)	26	34	37
Expected value (EV, $ million)	24	57	74
Expected rate of return (percent)	11	14	15

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Table 16. Results as a function of the cost of capital

Characteristic	Cost-of-Capital			
	5 Percent	8 Percent	12 Percent	15 Percent
Total exploration expenditures ($ million)	1,064	1,064	1,064	1,064
Number of economic deposits	23	23	21	19
Time periods (years)				
Exploration	8	8	8	9
Development (maximum)	5	5	5	5
Production (maximum)	48	48	48	48
Overall time period	57	57	57	58
Undiscounted values ($ million)				
Revenue	1,439	1,439	1,400	1,452
Less: Exploration expenditure	46	46	51	56
Development capital cost	66	66	62	55
Production cost	671	671	612	613
Cash flow	656	656	675	728
Economic indicators – start of development				
Net present value ($ million)	264	165	104	80
Rate of return (percent)	33	33	36	40
Economic indicators – start of exploration				
Average return (R, $ million)	182	91	40	22
Average exploration expenditure (E, $ million)	38	34	31	29
Expected value (EV, $ million)	144	57	9	−7
Expected rate of return (percent)	14	14	14	13

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Table 17. Effect of the exploration-development time gap

Characteristic	Base Case	Exploration-Development Time Gap			
		2 Years	4 Years	6 Years	8 Years
Total exploration expenditures ($ million)	1,064	1,064	1,064	1,064	1,064
Number of economic deposits	23	23	23	23	23
Time periods (years)					
Exploration	8	8	8	8	8
Time gap	0	2	4	6	8
Development (maximum)	5	5	5	5	5
Production (maximum)	48	48	48	48	48
Overall time period	57	59	61	63	65
Undiscounted values ($ million)					
Revenue	1,439	1,439	1,439	1,439	1,439
Less: Exploration expenditure	46	46	46	46	46
Development capital cost	66	66	66	66	66
Production cost	671	671	671	671	671
Cash flow	656	656	656	656	656
Economic indicators – start of development					
Net present value ($ million)	165	165	165	165	165
Rate of return (percent)	33	33	33	33	33
Economic indicators – start of exploration					
Average return (R, $ million)	91	78	67	58	50
Average exploration expenditure (E, $ million)	34	34	34	34	34
Expected value (EV, $ million)	57	44	33	24	16
Expected rate of return (percent)	14	12	10	9	8

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Table 18. Effect of the multi-billion dollar discovery

Characteristic	With Thompson Main	Without Thompson Main
Total exploration expenditures ($ million)	1,064	1,064
Number of economic deposits	23	22
Time periods (years)		
Exploration	8	8
Development (maximum)	5	5
Production (maximum)	48	37
Overall time period	57	46
Economic indicators – start of development		
Net present value ($ million)	165	86
Rate of return (percent)	33	24
Economic indicators – start of exploration		
Average return (R, $ million)	91	46
Average exploration expenditure (E, $ million)	34	35
Expected value (EV, $ million)	57	11
Expected rate of return (percent)	14	9

Note: overall time period is less than the sum of the component periods to the extent that there is overlap between the development and production phases.

Appendix VII

Income and Mining Taxation Systems

Taxation Systems in Manitoba

Federal Corporate Income Tax

This outline reflects important federal tax reform proposals which were enacted in September 1988. The rules apply from 1990.

Cash Flow Format

Revenue
Less: Operating Cost
Capital Cost Allowance
Interest Payments
Development Expenditure Allowance

If negative: Carried Loss

Revenue
Less: Operating Cost

Net Income before Allowances
Less: Capital Cost Allowance

Resource Profits
Less: Resource Allowance
Interest Payments
Exploration Expenditures
Development Expenditure Allowance

Income for Carried Loss
Less: Carried Loss (from year X-1 or X+1)

Income for Federal Corporate Income Tax
Federal Corporate Income Tax Otherwise Payable
Less: Investment Tax Credit

Net Federal Corporate Income Tax Payable

Capital Cost Allowance: applied to mine plant and machinery, mill facility, and infrastructure capital. The amount allowable must be reduced by the investment tax credit (see below).

The deduction permitted is 12.5 percent of the allowable capital cost in the year of expenditure and 25 percent per year thereafter on a declining balance basis. A company is entitled to claim any amount of capital cost allowance up to the maximum permitted.

Resource Allowance: 25 percent of resource profits.

In effect, the resource allowance reduces the effective federal rate of tax by one-quarter from 28 percent to 21 percent [28 percent − .25(28 percent)], but without reducing tax credits related to debt financing, exploration expenditures, and development expenditures.

Interest Payments: deductible in the year incurred to the extent of corporate income from any source. Any balance not currently deductible can be carried back three years or forward indefinitely for deduction in future years.

Exploration Expenditures: cannot be used to increase a loss. They are deductible in a given year only if there is a positive income (i.e. a positive difference between revenue and all other deductions and allowances).

Development Expenditure Allowance: applies to the cost of mine shafts, declines, main haulage ways, and similar underground work undertaken before and after the start-up of production; and to waste-stripping costs incurred prior to commencement of commercial production.[43]

These expenditures are deducted at up to 30 percent per year on a declining-balance basis. The deduction may be claimed whether or not the corporation has income. In other words, the development expenditure allowance can be used to create a loss for the carryback/carryforward rules.

The acquisition costs of Canadian resource properties are also eligible for the development expenditure allowance. Similarly, when a company disposes of a Canadian resource property, the proceeds are applied to reduce the balance available for determining this allowance. If the balance becomes "negative," this amount is included in income.

Carried Loss: losses can be carried forward seven years and back three years.

Federal Corporate Income Tax: the net rate of corporate federal tax applicable to taxable income is 28 percent, computed as follows:

Basic rate	38%
Less: Provincial abatement	(10)%
Net federal tax rate	28%

The 10 percent abatement of federal tax is designed to allow the provinces and territories room to impose corporate income taxes.

There is also a 3 percent federal surtax which was to be eliminated once sales tax reform was legislated. Since it was not removed at that time, it can be regarded as "permanent." Thus, the effective federal corporate tax rate is 28(1.03) = 28.84 percent.

[43] Overburden removal costs after the start of production are treated as current operating costs.

Investment Tax Credit: applies to mine plant and machinery, mill facility and infrastructure capital. The investment tax credit is deducted from the federal corporate income tax which would otherwise be payable to determine the net tax payable. The maximum deduction in any year is 75 percent of the federal corporate income tax otherwise payable. Excess credits may be carried back for three years and forward for ten years.

The rate of tax credit is 15 percent for applicable investment in the Atlantic Provinces and the Gaspé region of Québec.

Manitoba Corporate Income Tax

Income for Manitoba corporate income tax is derived in exactly the same way as income for federal corporate income tax. The applicable tax rate is 17 percent.

Manitoba Mining Tax

Cash Flow Format:

Revenue
Less: Operating Cost

Net Income before Allowances
Less: Depreciation Allowance
Exploration Expenditures

Income for Processing Allowance
Less: Processing Allowance

Income for Manitoba Mining Tax
Manitoba Mining Tax

Depreciation Allowance: all capital costs at 20 percent per year on a declining--balance basis.

Processing Allowance: average of 8 percent per year of the original cost of processing assets[44] but not to be more than 65 percent of income for processing allowance.

Manitoba Mining Tax: 20 percent of income for Manitoba mining tax.

[44] The May 1979 Manitoba Budget increased the processing allowance rate from 8 percent to 10 percent per year but restricted the definition of processing assets to exclude common service facilities. Thus, assume 8 percent as an average rate on all processing assets.

Provincial and Territorial Corporate Income Taxation Elsewhere in Canada

Québec

From 1990, income for Québec corporate income tax will be calculated in the same manner as income for federal corporate income tax.

The only difference will be that the acquisition costs of Québec resource properties are deductible at a 100 percent rate for Québec corporate income tax as compared to 30 percent per year declining balance for federal corporate income tax (as part of the "development expenditure allowance").

The basic Québec corporate income tax rate is 5.5 percent. Also, a 12 percent surtax is levied from July, 1989 (a 7.25 percent surtax had previously applied). Since there is no indication that this surtax has a time limit, the effective Québec corporate tax rate is 5.5(1.12) = 6.2 percent.

Ontario

Ontario's "percentage depletion allowance" is being phased out over a five-year period and, at the same time, the "resource allowance" is being phased in, as follows.

Year	Percentage Depletion Allowance	Resources Allowances
1988	33 1/3%	–
1989	26 2/3%	5%
1990	20%	10%
1991	13 1/3%	15%
1992	6 2/3%	20%
1993	–	25%

Thus, from 1993, income for Ontario corporate income tax will be determined in the same way as income for federal corporate income tax.

The only difference will be that the acquisition costs of Ontario resource properties are deductible at a 100 percent rate for Ontario corporate income tax as compared to 30 percent per year declining balance for federal corporate income tax (as part of the "development expenditure allowance").

The Ontario corporate income tax rate is 14.5 percent.

British Columbia

In British Columbia, the "resource allowance" is not an allowable deduction in calculating income for B.C. corporate income tax. Otherwise, income is determined in the same way as for federal tax.

The corporate income tax rate in British Columbia is 14 percent.

Other Provinces and Territories

Income for provincial and territorial income tax is determined in the same way as for federal corporate income tax. The applicable rates are as follows.

Alberta	15%
New Brunswick	16%
Newfoundland	17%
Northwest Territories	10%
Nova Scotia	15%
Saskatchewan	15%
Yukon Territory	10%

Provincial and Territorial Mining Taxation Elsewhere in Canada

Newfoundland[45]

Cash Flow Format:

Revenue
Less: Operating Cost

Net Income before Allowances
Less: Depreciation Allowance
Exploration Expenditures

Income for Processing Allowance
Less: Processing Allowance

Income for Newfoundland Mining Tax
Newfoundland Mining Tax

Depreciation Allowance: all pre-production capital costs allowable on a straight-line basis over estimated, mine life. Capital expended during the productive life of a mine is allowable at 10 percent on a straight-line basis.

Processing Allowance: 8 percent per year of the original cost of processing assets but not to be more than 65 percent of the income for processing allowance.

Newfoundland Mining Tax: 20 percent on first 20 percent of income for Newfoundland mining tax; 15 percent on remaining income for Newfoundland mining tax.

[45] Several mining companies have special royalty agreements with the Newfoundland government which override the general mining taxation policies outlined here. For example, the operations of the Iron Ore Company of Canada are governed by the Labrador Mining and Exploration Act of 1938 as amended. The method by which the province derives revenue from Wabush Mines' iron ore operation is determined by the Nalco-Javelin Mineral Lands Act as amended.

Base metal and gold deposits discovered on the Anglo-Newfoundland Development (AND) charter lands in the Buchans area, presently controlled by the Selco Division of BP Resources, are subject to the provisions of the Manufacture of Pulp and Paper Act of 1905 as amended. A royalty of 5 percent of taxable income is in this case payable. Depreciation allowance is 10 percent of capital costs per year on a straight-line basis. There is no processing allowance.

The application of such special arrangements is not considered in the present study.

Nova Scotia

Cash Flow Format:

Gross Metal Revenue
Less: Smelting, Refining, and Transportation Charges

Revenue = Net Smelter Return

Revenue
Less: Operating Cost

Net Income before Allowances
Less: Depreciation Allowance
Exploration Expenditures

Income for Processing Allowance
Less: Processing Allowance

Income for Nova Scotia Mining Tax
Nova Scotia Mining Tax

Depreciation Allowance: all capital costs except post-production mine access capital costs allowable at 100 percent against new mine income during the first three years of operation and at 30 percent per year on a straight-line basis thereafter. Post-production mine development capital costs allowable at 100 percent.

Processing Allowance: 8 percent per year of the original cost of processing assets but not to be less than 15 percent nor more than 65 percent of the income for processing allowance.

Nova Scotia Mining Tax: the greater of 2 percent of net smelter return or 15 percent of income for Nova Scotia mining tax (but subject to change by order-in-council).

New Brunswick

Cash Flow Format:

Revenue
Less: Operating Cost
Exploration Allowance
Royalty
Depreciation Allowance
Interest Allowance

Income for Processing Allowance
Less: Processing Allowance

Income for New Brunswick Mining Tax
New Brunswick Mining Tax
Less: Research Credit

New Brunswick Mining Tax after Credit

Exploration Allowance: $1.50 for every $1 of exploration expenditures.

Royalty: 2 percent of "net mill return" starting in the third year of mine operation.

Gross Metal Revenue
Less: Smelting, Refining, and Transportation Charges

Revenue
Less: Mill Operating Costs

Return for Processing Allowance
Less: Processing Allowance

Net Mill Return (i.e. value of the mill feed)

The processing allowance is determined as specified below but the amount deductible in any year cannot exceed 25 percent of the "return for processing allowance."

Depreciation Allowance: applies to all capital expenditures, including development, but excluding exploration and research.

For all qualifying capital expenditures, the deduction permitted each year is up to 33 1/3 percent of the capital cost on a straight-line basis with no minimum deduction.

Interest Allowance: 8 percent per year of the undepreciated cost of all assets qualifying for depreciation allowance. Note that it may in some cases be advantageous to depreciate more slowly than possible to take fuller advantage of this allowance.

Processing Allowance: annual rate applied to the original cost of processing assets but not to be less than 15 percent nor more than 65 percent of income for processing allowance.

8 percent of concentrator assets.
15 percent of smelting and refining assets.

New Brunswick Mining Tax:

income for mining tax	marginal rate
up to $100,000	exempt
$100,000 and over	16%

Research Credit: 25 percent of pre-approved research expenditures incurred anywhere which are intended to increase mineral production in New Brunswick. Unused credits may be carried forward indefinitely.

Québec

Cash Flow Format:

Revenue
Less: Operating Cost

If negative: Carried Loss

Revenue
Less: Operating Cost
Depreciation Allowance
Exploration Expenditures

Income for Exploration and Investment Allowance
Less: Exploration and Investment Allowance

Income for Processing Allowance
Less: Processing Allowance

Income for Québec Mining Tax
Québec Mining Tax Otherwise Payable
Less: Carried Credit for Unused Exemption
Deduction for Carried Loss

Net Québec Mining Tax Payable
Refundable Credit

Depreciation Allowance: mine development capital costs at 100 percent per year; all other capital costs at 30 percent per year on a straight-line basis.

Exploration and Investment Allowance: $1 for every $3 of pre-production exploration expenditures, capital costs of processing facilities, and exploration costs incurred at operating underground mines,[46] up to a maximum of 33 1/3 percent of income for exploration and investment allowance in any year.

[46] Actually limited to a prescribed list of exploration expenditures which are a function of such factors as depth of exploration and distance from mine workings.

Processing Allowance: annual rate applied to the original cost of processing assets but not to be less than 15 percent nor more than 65 percent of income for processing allowance.

8 percent if ore concentrated
15 percent if concentrate is smelted and/or refined in Québec

Rate applies to all processing assets up to and including final stage.

The 15 percent rate applies to gold mill assets if the facility includes a smelter which produces doré or impure bullion.

Québec Mining Tax Otherwise Payable:

income for mining tax	marginal rate
up to $500,000	exempt
$500,000 and over	18%

At the 18 percent tax rate, the $500,000 exemption is equivalent to a credit of $90,000. Any part of the credit which is not used during a given year may be carried forward three years.

Deduction for Carried Loss: 18 percent of "carried loss" in the year following the loss. This deduction can be carried back three years and ahead seven years.

Refundable Credit: 18 percent of the loss resulting from exploration expenditures and depreciation allowance during a given year, up to the limit of 18 percent of the loss incurred during the year.

Revenue
Less: Operating Cost
Depreciation Allowance
Exploration Expenditures

If negative: Loss Incurred during Year

Ontario

Cash Flow Format:

Revenue
Less: Operating Cost

Net Income before Allowances
Less: Depreciation Allowance
Exploration Expenditures

Income for Processing Allowance
Less: Processing Allowance

Income for Ontario Mining Tax
Ontario Mining Tax

Depreciation Allowance: mine development capital costs at 100 percent per year; mine plant and equipment at 30 percent per year on a straight-line basis; mill, infrastructure and all other capital costs at 15 percent per year on a straight-line basis.

Processing Allowance: annual rate applied to the original cost of processing assets but not to be less than 15 percent nor more than 65 percent of income for processing allowance.

8 percent if ore concentrated
12 percent if ore smelted in Canada
16 percent if ore refined in Canada
20 percent if ore refined or fabricated in northern Ontario

Rate applies to all processing assets up to and including final stage.

The 12 percent rate applies to gold mill assets if the facility includes a smelter which produces doré or impure bullion.

Three-Year Tax-Exempt Period: a new mine is exempt from Ontario mining tax for a period of three years from the start of production. Discretionary deductions for exploration and development costs are not required to be deducted in determining the amount of exempt income. These deductions can be saved and used later, after the expiry of the exempt period.

Ontario Mining Tax:

income for mining tax	marginal rate
up to $500,000	exempt
$500,000 and over	20%

Saskatchewan - Metallic Minerals Royalty

Cash Flow Format:

Revenue
Less: Operating Cost

Net Income before Allowances
Less: Depreciation Allowance
Exploration Expenditures

Income for Processing Allowance
Less: Processing Allowance

Income for Saskatchewan Mining Tax
Saskatchewan Mining Tax

Depreciation Allowance: mine development expenditures and mine plant and machinery capital costs allowable at 100 percent. Capital costs of processing, housing, and townsite facilities allowable at 30 percent per year on a declining-balance basis. For capital expenditures for road and power facilities, assume half is written off at 100 percent, and the other half at 30 percent per year, declining-balance. Assume 70 percent of infrastructure capital expenditures is deducted at 30 percent per year declining-balance, and the remaining 30 percent of the infrastructure at 100 percent.

Processing Allowance: 8 percent per year of the original cost of processing assets but not to be less than 20 percent nor more than 65 percent of the income for processing allowance for copper-zinc deposits, and not to be less than 15 percent or more than 65 percent of income for other deposits.

Saskatchewan Mining Tax: 12.5 percent of income for Saskatchewan mining tax.

Alberta - Metallic Minerals.

Payout: date on which the cumulative gross revenue of the mine equals the sum of cumulative allowed capital costs, cumulative operating costs, cumulative on-site exploration and development costs, cumulative annual capital allowance, and cumulative pre-payout royalty.

Allowed Capital Costs: includes all capital expenditures directly attributable to the mine except for exploration expenditures, development costs, and working capital. Included in this category is an allowance for indirect capital costs of 1 percent of the capital costs incurred.

Operating Costs: includes smelting, refining, and transportation charges, and all other operating costs directly attributable to the mine.

Annual Capital Allowance: 15 percent of the unrecovered allowed capital costs in a year. Where the period to which the allowance applies is less than a full year, the allowance must be reduced to reflect the eligible period of the year.

Cash Flow Format: applies before payout is achieved, and defines mine mouth revenue after payout occurs.

Gross Revenue
Less: Smelting, Refining and Transportation Charges
Mill Operating Costs
Annual Capital Allowance on Processing Capital Expenditures

Mine Mouth Revenue

Alberta Pre-Payout Royalty: 1 percent of mine mouth revenue.

Cash Flow Format for Post-Payout Royalty: applies after payout occurs.

Gross Revenue
Less: Allowed Capital Costs
Operating Costs
On-Site Exploration and Development Costs

Revenue for Processing Allowance
Less: Processing Allowance
Operating Losses from Prior Years
Off-Site Exploration Costs

If negative: Carried Loss for Next Year
If positive: Net Revenue

Allowed Capital Costs: permits 100 percent write-down of allowed capital expenditures in the year of acquisition. Included in this category is an allowance for indirect capital costs of 1 percent of the capital costs incurred.

Processing Allowance: 10 percent per year of the original cost of processing assets but not to be more than 65 percent of the revenue for processing allowance.

Operating Losses: may be carried forward until recovered. The calculation of an operating loss excludes royalty paid.

Off-Site Exploration Costs: incurred in Alberta before the commencement of mining operations.

Alberta Post-Payout Royalty: the greater of 1 percent of mine mouth revenue or 12 percent of net revenue.

Northwest Territories

Cash Flow Format:

Revenue
Less: Operating Cost

Net Income before Allowances
Less: Depreciation Allowance
Exploration Expenditures

Income for Processing Allowance
Less: Processing Allowance

Income for Northwest Territories Mining Tax
Northwest Territories Mining Tax

Depreciation Allowance: all capital costs except post-production mine development capital costs allowable at 15 percent per year on a straight-line basis; post-production mine development capital costs at 100 percent.

Processing Allowance: 8 percent per year of the original cost of processing assets but not to be less than 15 percent nor more than 65 percent of the income for processing allowance.

Northwest Territories Mining Tax:

income for mining tax	marginal rate
up to $10,000	exempt
$10,000 - 1 million	3%
$1 million - 5 million	5%
$5 million - 10 million	6%
$10 million and over	+ 1% for each additional $5 million up to 12% maximum

Yukon Territory

Cash Flow Format:

Revenue
Less: Operating Cost

Net Income before Allowances
Less: Depreciation Allowance
Exploration Expenditures

Income for Yukon Mining Tax
Yukon Mining Tax

Depreciation Allowance: all capital costs except post-production mine development capital costs allowable at 15 percent per year on a straight-line basis; post-production mine development capital costs at 100 percent.

Yukon Mining Tax:

income for mining tax	marginal rate
up to $10,000	exempt
$10,000 - 1 million	3%
$1 million to 10 million	5%
$5 million - 10 million	6%
$10 million and over	+ 1% for each additional $5 million up to 12% maximum

British Columbia

Cash Flow Format:

Revenue
Less: Operating Cost

Net Current Proceeds, if positive (NCP)
NCP Tax at 2.0%

Revenue
Less: Operating Cost
Cumulative Expenditure (CE) from year X - 1
Capital Expenditure

Net Revenue (NR)
- If negative: carried forward with investment allowance as CE for year X + 1
- If positive: for net revenue tax
  NR Tax at 13.0%

Less: Cumulative Tax Credit (CTC) from X - 1
NCP Tax

- If negative: carried forward with investment allowance as CTC for year X + 1
- If positive: NR Tax Payable

British Columbia Mining Tax Payable = NCP Tax + NR Tax Payable

Capital Expenditure: all capital costs except for working capital

Investment Allowance: 1.25 (average Bank of Canada lending rate for year X)

Note: taxation is on an individual-project basis

Rates Used to Calculate Tax Credits Associated with Exploration Expenditures

Manitoba	65.8%	
Newfoundland	61.8%	
Nova Scotia	58.8%	
New Brunswick	68.8%	(allows for special exploration write-off)
Quebec	59.0%	(allows for 12% surtax, and investment allowance)
Ontario	63.3%	
Saskatchewan	56.3%	
Alberta	55.8%	
British Columbia	55.8%	
Northwest Territory	46.8%	(assumes 6% marginal mining tax rate)
Yukon Territory	46.8%	(assumes 6% marginal mining tax rate)

Appendix VIII

After-Tax Evaluation Results: Current Manitoba Taxation System

Table 19. After-tax results under base case conditions

Characteristic	Potential Value	After-Tax Value
Total exploration expenditures ($ million)	1,064	1,064
Number of economic deposits	23	19
Time periods (years)		
Exploration	8	9
Development (maximum)	5	5
Production (maximum)	48	48
Overall time period	57	58
Undiscounted values ($ million)		
Revenue	1,439	1,498
Less: Exploration expenditure	46	56
Development capital cost	66	57
Production cost	671	648
Net tax payments		397
Cash flow	656	340
Economic indicators – start of development		
Net present value ($ million)	165	77
Rate of return (percent)	33	24
Economic indicators – start of exploration		
Average return (R, $ million)	91	38
Average exploration expenditure (E, $ million)	34	13
Expected value (EV, $ million)	57	25
Expected rate of return (percent)	14	13

Note: overall time period is less than the sum of the component periods when there is overlap between the development and production phases.

Table 20. Mining taxation criteria under base case conditions

Criterion	Start of Exploration	Start of Development
Number of economic deposits	19	19
Net undiscounted tax revenues ($ million)		
Federal income tax	156	172
Provincial income tax	92	102
Provincial mining tax and royalty	149	160
Total	397	434
Net tax revenues discounted at 8 percent ($ million)		
Federal income tax	11	45
Provincial income tax	6	27
Provincial mining tax and royalty	14	43
Total	31	115
Effective tax rates (percent)		
Federal income tax	20	23
Provincial income tax	11	14
Provincial mining tax and royalty	24	23
Total	55	60
Government tax shares (percent)		
Federal government	35	39
Provincial government	65	61

Table 21. After-tax results as a function of metal price

Characteristic	Price Variant		
	Lower-Limit	Expected	Upper-Limit
Total exploration expenditures ($ million)	1,064	1,064	1,064
Number of economic deposits	3	19	41
Time periods (years)			
Exploration	59	9	4
Development (maximum)	3	5	5
Production (maximum)	47	48	48
Overall time period	109	58	53
Undiscounted values ($ million)			
Revenue	2,506	1,498	1,743
Less: Exploration expenditure	355	56	26
Development capital cost	102	57	70
Production cost	1,671	648	531
Net tax payments	170	397	607
Cash flow	208	340	509
Economic indicators – start of development			
Net present value ($ million)	46	77	128
Rate of return (percent)	15	24	30
Economic indicators – start of exploration			
Average return (R, $ million)	0	38	92
Average exploration expenditure (E, $ million)	25	13	7
Expected value (EV, $ million)	– 25	25	85
Expected rate of return (percent)	2	13	23

Note: overall time period is less than the sum of the component periods when there is overlap between the development and production phases.

Table 22. Mining taxation criteria from the start of exploration as a function of metal price

	Price Variant	
	Expected	Upper-Limit
Number of economic deposits	19	41
Net undiscounted tax revenues ($ million)		
Federal income tax	156	240
Provincial income tax	92	141
Provincial mining tax and royalty	149	226
Total	397	607
Net tax revenues discounted at 8 percent ($ million)		
Federal income tax	11	44
Provincial income tax	6	26
Provincial mining tax and royalty	14	44
Total	31	114
Effective tax rates (percent)		
Federal income tax	20	22
Provincial income tax	11	13
Provincial mining tax and royalty	24	22
Total	55	57
Government tax shares (percent)		
Federal government	35	39
Provincial government	65	61

Table 23. Mining taxation criteria from the start of development as a function of metal price

	Price Variant		
	Lower-Limit	Expected	Upper-Limit
Number of economic deposits	3	19	41
Net undiscounted tax revenues ($ million)			
Federal income tax	160	172	247
Provincial income tax	94	102	146
Provincial mining tax and royalty	149	160	231
Total	403	434	624
Net tax revenues discounted at 8 percent ($ million)			
Federal income tax	39	45	70
Provincial income tax	23	27	42
Provincial mining tax and royalty	38	43	67
Total	100	115	179
Effective tax rates (percent)			
Federal income tax	27	23	23
Provincial income tax	16	14	13
Provincial mining tax and royalty	26	23	22
Total	69	60	58
Government tax shares (percent)			
Federal government	39	39	39
Provincial government	61	61	61

Appendix IX

After-Tax Evaluation Results: Manitoba's Competitive Position in Canada

Table 24. Manitoba's competitive position: interprovincial comparison of after-tax results, at expected prices

Characteristic	Manitoba	Newfoundland	Nova Scotia	New Brunswick
Total exploration expenditures ($ million)	1,064	1,064	1,064	1,064
Number of economic deposits	19	20	22	20
Time periods (years)				
Exploration	9	9	8	9
Development (maximum)	5	5	5	5
Production (maximum)	48	48	48	48
Overall time period	58	58	57	58
Undiscounted values ($ million)				
Revenue	1,498	1,456	1,491	1,456
Less: Exploration expenditure	56	53	48	53
Development capital cost	57	59	64	59
Production cost	648	638	697	638
Net tax payments	397	348	270	337
Cash flow	340	358	412	369
Economic indicators – start of development				
Net present value ($ million)	77	83	81	87
Rate of return (percent)	24	25	24	26
Economic indicators – start of exploration				
Average return (R, $ million)	38	42	48	44
Average exploration expenditure (E, $ million)	13	14	14	12
Expected value (EV, $ million)	25	28	34	32
Expected rate of return (percent)	13	13	14	15

Québec	Ontario	Saskatchewan	Alberta	Northwest Territories	Yukon Territory	British Columbia
1,064	1,064	1,064	1,064	1,064	1,064	1,064
22	21	21	22	22	22	21
8	8	8	8	8	8	8
5	5	5	5	5	5	5
48	48	48	48	48	48	48
57	57	57	57	57	57	57
1,491	1,539	1,539	1,491	1,491	1,491	1,539
48	51	51	48	48	48	51
64	63	63	64	64	64	63
697	716	716	697	697	697	716
279	335	310	293	260	273	346
403	374	399	389	422	409	363
92	88	89	90	99	95	81
25	26	24	24	26	25	24
49	46	47	48	53	51	43
14	13	16	15	18	18	16
35	33	31	33	35	33	27
14	14	13	14	13	13	13

Table 25. Manitoba's competitive position: interprovincial comparison of mining taxation criteria from the start of exploration, at expected prices

Criterion	Manitoba	Newfoundland	Nova Scotia	New Brunswick
Number of economic deposits	19	20	22	20
Net undiscounted tax revenues ($ million)				
Federal income tax	156	143	138	142
Provincial income tax	92	89	77	84
Provincial mining tax and royalty	149	116	55	111
Total	397	348	270	337
Net tax revenues discounted at 8 percent ($ million)				
Federal income tax	11	10	10	10
Provincial income tax	7	7	7	7
Provincial mining tax and royalty	13	11	6	7
Total	31	28	23	24
Effective tax rates (percent)				
Federal income tax	20	17	18	17
Provincial income tax	11	13	12	12
Provincial mining tax and royalty	24	21	10	13
Total	55	51	40	42
Government tax shares (percent)				
Federal government	35	34	46	41
Provincial government	65	66	54	59
Comparative tax levels (Manitoba = 100)				
Federal income tax	100	89	98	89
Provincial income tax	100	108	104	102
Provincial mining tax and royalty	100	89	45	55
Overall	100	93	76	77

Québec	Ontario	Saskatchewan	Alberta	Northwest Territories	Yukon Territory	British Columbia
22	21	21	22	22	22	21
145	151	151	145	145	145	151
31	76	79	76	50	50	102
103	108	80	72	65	78	93
279	335	310	293	260	273	346
12	12	12	12	12	12	12
3	6	7	7	4	4	10
8	7	8	6	7	9	9
23	25	27	25	23	25	31
21	21	21	21	21	21	21
4	11	11	11	8	8	18
14	11	14	11	11	14	15
39	43	46	43	40	43	54
54	49	45	50	54	50	39
46	51	55	50	46	50	61
113	111	111	113	113	113	111
41	95	98	100	67	67	156
59	48	62	45	48	62	66
75	80	87	80	75	81	101

Table 26. Manitoba's competitive position: interprovincial comparison of mining taxation criteria from the start of development, at expected prices

Criterion	Manitoba	Newfoundland	Nova Scotia	New Brunswick
Number of economic deposits	19	20	22	20
Net undiscounted tax revenues ($ million)				
Federal income tax	172	158	152	158
Provincial income tax	102	98	84	93
Provincial mining tax and royalty	160	125	62	123
Total	434	381	298	374
Net tax revenues discounted at 8 percent ($ million)				
Federal income tax	45	41	38	40
Provincial income tax	27	26	22	25
Provincial mining tax and royalty	43	35	21	32
Total	115	102	81	97
Effective tax rates (percent)				
Federal income tax	23	22	22	22
Provincial income tax	14	14	13	13
Provincial mining tax and royalty	23	19	12	18
Total	60	55	47	53
Government tax shares (percent)				
Federal government	39	40	47	42
Provincial government	61	60	53	58
Comparative tax levels (Manitoba = 100)				
Federal income tax	100	90	85	90
Provincial income tax	100	99	83	93
Provincial mining tax and royalty	100	82	48	75
Overall	100	89	71	85

Québec	Ontario	Saskatchewan	Alberta	Northwest Territories	Yukon Territory	British Columbia
22	21	21	22	22	22	21
159	166	166	159	159	159	166
34	83	86	83	55	55	109
114	118	86	78	69	82	100
307	367	338	320	283	296	375
41	43	43	41	41	41	43
9	22	22	22	15	15	29
30	26	25	19	17	20	26
80	91	90	82	73	76	98
24	24	24	24	24	24	24
5	12	12	13	8	8	16
18	15	14	11	10	12	15
47	51	50	48	42	44	55
52	47	48	51	57	54	44
48	53	52	49	43	46	56
92	95	95	92	92	92	95
33	81	84	81	54	54	108
70	60	57	44	40	47	60
70	79	78	71	64	67	85

Table 27. Manitoba's competitive position: interprovincial comparison of after-tax results, at lower-limit prices

Characteristic	Manitoba	Newfoundland	Nova Scotia	New Brunswick
Total exploration expenditures ($ million)	1,064	1,064	1,064	1,064
Number of economic deposits	3	3	3	3
Time periods (years)				
Exploration	59	59	59	59
Development (maximum)	3	3	3	3
Production (maximum)	47	47	47	47
Overall time period	108	108	108	108
Undiscounted values ($ million)				
Revenue	2,506	2,506	2,506	2,506
Less: Exploration expenditure	355	355	355	355
Development capital cost	102	102	102	102
Production cost	1,671	1,671	1,671	1,671
Net tax payments	170	145	85	122
Cash flow	208	233	293	256
Economic indicators – start of development				
Net present value ($ million)	46	54	71	61
Rate of return (percent)	15	15	18	17
Economic indicators – start of exploration				
Average return (R, $ million)	0	0	1	1
Average exploration expenditure (E, $ million)	25	28	31	23
Expected value (EV, $ million)	– 25	– 28	– 30	– 22
Expected rate of return (percent)	2	2	2	2

Québec	Ontario	Saskatchewan	Alberta	Northwest Territories	Yukon Territory	British Columbia
1,064	1,064	1,064	1,064	1,064	1,064	1,064
3	3	3	3	3	3	3
59	59	59	59	59	59	59
3	3	3	3	3	3	3
47	47	47	47	47	47	47
108	108	108	108	108	108	108
2,506	2,506	2,506	2,506	2,506	2,506	2,506
355	355	355	355	355	355	355
102	102	102	102	102	102	102
1,671	1,671	1,671	1,671	1,671	1,671	1,671
102	130	132	128	117	130	167
276	248	246	250	261	248	211
70	65	62	67	77	74	57
18	18	16	17	18	18	16
0	0	0	1	0	0	1
30	27	32	33	39	39	33
− 30	− 27	− 32	− 32	− 39	− 39	− 32
2	2	2	2	2	1	2

Table 28. Manitoba's competitive position: interprovincial comparison of after-tax results, at upper-limit prices

Characteristic	Manitoba	Newfoundland	Nova Scotia	New Brunswick
Total exploration expenditures ($ million)	1,064	1,064	1,064	1,064
Number of economic deposits	41	41	41	41
Time periods (years)				
Exploration	4	4	4	4
Development (maximum)	5	5	5	5
Production (maximum)	48	48	48	48
Overall time period	53	53	53	53
Undiscounted values ($ million)				
Revenue	1,743	1,743	1,743	1,743
Less: Exploration expenditure	26	26	26	26
Development capital cost	70	70	70	70
Production cost	531	531	531	531
Net tax payments	607	559	483	543
Cash flow	509	557	633	573
Economic indicators – start of development				
Net present value ($ million)	128	143	164	150
Rate of return (percent)	30	31	34	33
Economic indicators – start of exploration				
Average return (R, $ million)	92	102	117	108
Average exploration expenditure (E, $ million)	7	8	9	7
Expected value (EV, $ million)	85	94	108	101
Expected rate of return (percent)	23	24	25	26

Québec	Ontario	Saskatchewan	Alberta	Northwest Territories	Yukon Territory	British Columbia
1,064	1,064	1,064	1,064	1,064	1,064	1,064
41	41	41	41	41	41	41
4	4	4	4	4	4	4
5	5	5	5	5	5	5
48	48	48	48	48	48	48
53	53	53	53	53	53	53
1,743	1,743	1,743	1,743	1,743	1,743	1,743
26	26	26	26	26	26	26
70	70	70	70	70	70	70
531	531	531	531	531	531	531
462	529	489	484	431	451	545
654	587	627	632	685	665	571
171	160	162	169	182	176	148
35	36	33	36	36	36	32
123	115	116	121	130	126	105
9	8	9	9	11	11	9
114	107	107	112	119	115	96
26	27	25	26	25	25	24

Table 29. Manitoba's competitive position: interprovincial comparison of mining taxation criteria from the start of exploration, at upper-limit prices

Criterion	Manitoba	Newfoundland	Nova Scotia	New Brunswick
Number of economic deposits	41	41	41	41
Net undiscounted tax revenues ($ million)				
Federal income tax	240	235	235	235
Provincial income tax	141	142	126	134
Provincial mining tax and royalty	226	182	121	174
Total	607	559	481	543
Net tax revenues discounted at 8 percent ($ million)				
Federal income tax	44	42	42	42
Provincial income tax	26	27	23	25
Provincial mining tax and royalty	44	36	25	31
Total	114	105	90	98
Effective tax rates (percent)				
Federal income tax	21	21	21	21
Provincial income tax	13	14	12	12
Provincial mining tax and royalty	22	18	12	16
Total	57	53	45	49
Government tax shares (percent)				
Federal government	39	40	47	43
Provincial government	61	60	53	57
Comparative tax levels (Manitoba = 100)				
Federal income tax	100	95	95	95
Provincial income tax	100	101	89	95
Provincial mining tax and royalty	100	83	57	71
Overall	100	92	79	86

Québec	Ontario	Saskatchewan	Alberta	Northwest Territories	Yukon Territory	British Columbia
41	41	41	41	41	41	41
240	240	240	240	240	240	240
51	121	125	125	83	83	159
171	168	124	119	108	128	146
462	529	489	484	431	451	545
44	44	44	44	44	44	44
10	22	23	23	15	15	30
31	26	25	20	20	24	28
85	92	92	87	79	83	102
22	22	22	22	22	22	22
5	11	12	12	8	8	15
16	13	12	10	10	12	14
43	46	46	44	40	42	51
52	48	48	51	56	53	43
48	52	52	49	44	47	57
100	100	100	100	100	100	100
36	85	88	88	59	59	117
71	58	57	45	45	55	63
74	81	81	76	70	76	90

Table 30. Manitoba's competitive position: interprovincial comparison of mining taxation criteria from the start of development, at lower-limit prices

Criterion	Manitoba	Newfoundland	Nova Scotia	New Brunswick
Number of economic deposits	3	3	3	3
Net undiscounted tax revenues ($ million)				
Federal income tax	160	142	142	142
Provincial income tax	94	97	86	92
Provincial mining tax and royalty	149	125	66	132
Total	403	364	294	366
Net tax revenues discounted at 8 percent ($ million)				
Federal income tax	39	32	32	32
Provincial income tax	23	24	21	23
Provincial mining tax and royalty	38	36	21	30
Total	100	92	74	85
Effective tax rates (percent)				
Federal income tax	27	22	22	22
Provincial income tax	16	16	15	15
Provincial mining tax and royalty	26	25	14	21
Total	69	63	51	58
Government tax shares (percent)				
Federal government	39	35	43	38
Provincial government	61	65	57	62
Comparative tax levels (Manitoba = 100)				
Federal income tax	100	84	83	83
Provincial income tax	100	104	92	98
Provincial mining tax and royalty	100	93	55	80
Overall	100	92	74	85

Québec	Ontario	Saskatchewan	Alberta	Northwest Territories	Yukon Territory	British Columbia
3	3	3	3	3	3	3
160	160	160	160	160	160	160
34	81	84	84	56	56	108
117	115	88	82	67	80	97
311	355	332	326	283	296	365
39	39	39	39	39	39	39
8	19	20	20	13	13	27
30	23	25	20	16	20	23
77	81	84	79	68	72	89
26	27	27	27	27	27	27
6	13	14	14	9	9	18
20	15	17	13	11	13	16
52	55	58	54	47	49	61
51	48	46	49	57	54	44
49	52	54	51	43	46	56
100	100	100	100	100	100	100
36	85	88	88	59	59	118
77	59	66	51	42	51	61
77	81	84	79	68	72	89

Table 31. Manitoba's competitive position: interprovincial comparison of mining taxation criteria from the start of development, at upper-limit prices

Criterion	Manitoba	Newfoundland	Nova Scotia	New Brunswick
Number of economic deposits	41	41	41	41
Net undiscounted tax revenues ($ million)				
Federal income tax	247	242	242	242
Provincial income tax	146	147	129	138
Provincial mining tax and royalty	231	186	127	180
Total	624	575	498	560
Net tax revenues discounted at 8 percent ($ million)				
Federal income tax	70	67	67	67
Provincial income tax	42	42	37	39
Provincial mining tax and royalty	67	55	39	51
Total	179	164	143	157
Effective tax rates (percent)				
Federal income tax	23	22	22	22
Provincial income tax	13	14	12	13
Provincial mining tax and royalty	22	18	13	16
Total	58	54	47	51
Government tax shares (percent)				
Federal government	39	41	47	43
Provincial government	61	59	53	57
Comparative tax levels (Manitoba = 100)				
Federal income tax	100	96	96	96
Provincial income tax	100	101	89	95
Provincial mining tax and royalty	100	82	58	76
Overall	100	92	80	88

Québec	Ontario	Saskatchewan	Alberta	Northwest Territories	Yukon Territory	British Columbia
41	41	41	41	41	41	41
247	247	247	247	247	247	247
53	124	129	129	86	86	162
177	175	127	122	110	130	150
477	546	503	498	443	463	559
70	70	70	70	70	70	70
15	35	37	37	25	25	47
51	42	38	31	30	36	42
136	147	145	138	125	136	159
23	23	23	23	23	23	23
5	12	12	12	8	8	15
16	13	12	10	10	13	14
44	48	47	45	41	44	52
52	48	48	51	56	52	44
48	52	52	49	44	48	56
100	100	100	100	100	100	100
36	85	88	88	59	59	113
75	62	57	46	45	54	63
76	82	81	77	70	76	89

Appendix X

After-Tax Evaluation Results: Manitoba Mining Taxation Options

Table 32. Manitoba mining taxation options: after-tax cash flow characteristics and expected values for an economic deposit, at expected prices

Characteristic	Base Case	Tax Option 1	Tax Option 2
Total exploration expenditures ($ million)	1,064	1,064	1,064
Number of economic deposits	19	19	20
Time periods (years)			
Exploration	9	9	9
Development (maximum)	5	5	5
Production (maximum)	48	48	48
Overall time period	58	58	58
Undiscounted values ($ million)			
Revenue	1,498	1,498	1,456
Less: Exploration expenditure	56	56	53
Development capital cost	57	57	59
Production cost	648	648	638
Net tax payments	397	392	366
Cash flow	340	345	340
Economic indicators – start of development			
Net present value ($ million)	77	77	83
Rate of return (percent)	24	24	27
Economic indicators – start of exploration			
Average return (R, $ million)	38	38	43
Average exploration expenditure (E, $ million)	13	10	13
Expected value (EV, $ million)	25	28	30
Expected rate of return (percent)	13	14	14

Tax Option 3	Tax Option 4	Tax Option 5	Tax Option 6
1,064	1,064	1,064	1,064
19	19	19	20
9	9	9	9
5	5	5	5
48	48	48	48
58	58	58	58
1,498	1,498	1,498	1,456
56	56	56	53
57	57	57	59
648	648	648	638
391	396	375	378
346	341	362	328
77	78	83	76
24	25	25	24
9	13	13	13
37	38	40	39
28	25	27	26
15	13	14	13

Table 33. Manitoba mining taxation options: taxation criteria from the start of exploration, at expected prices

Criterion	Base Case	Tax Option 1	Tax Option 2
Number of economic deposits	19	19	20
Net undiscounted tax revenues ($ million)			
Federal income tax	156	156	150
Provincial income tax	92	92	88
Provincial mining tax and royalty	149	144	128
Total	397	392	366
Net tax revenues discounted at 8 percent ($ million)			
Federal income tax	11	11	11
Provincial income tax	6	6	7
Provincial mining tax and royalty	14	10	9
Total	31	27	27
Effective tax rates (percent)			
Federal income tax	20	20	20
Provincial income tax	11	11	12
Provincial mining tax and royalty	24	18	15
Total	55	49	47
Government tax shares (percent)			
Federal government	35	40	43
Provincial government	65	60	57
Comparative tax levels (Manitoba = 100)			
Federal income tax	100	100	104
Provincial income tax	100	100	104
Provincial mining tax and royalty	100	75	64
Overall	100	89	87

Tax Option 3	Tax Option 4	Tax Option 5	Tax Option 6
19	19	19	20
156	156	156	150
92	92	92	88
143	148	127	140
391	396	375	378
11	11	11	11
6	6	6	7
10	13	11	12
27	30	28	30
20	20	20	20
11	11	11	12
17	24	19	22
48	55	50	54
41	36	39	37
59	64	61	63
100	100	100	104
100	100	100	104
71	97	80	93
87	98	91	99

Table 34. Manitoba mining taxation options: taxation criteria from the start of development, at expected prices

Criterion	Base Case	Tax Option 1	Tax Option 2
Number of economic deposits	19	19	20
Net undiscounted tax revenues ($ million)			
Federal income tax	172	172	165
Provincial income tax	101	101	97
Provincial mining tax and royalty	161	161	139
Total	434	434	401
Net tax revenues discounted at 8 percent ($ million)			
Federal income tax	45	45	44
Provincial income tax	27	27	26
Provincial mining tax and royalty	43	43	31
Total	115	115	101
Effective tax rates (percent)			
Federal income tax	23	23	24
Provincial income tax	14	14	14
Provincial mining tax and royalty	23	23	17
Total	60	60	55
Government tax shares (percent)			
Federal government	39	39	43
Provincial government	61	61	57
Comparative tax levels (Manitoba = 100)			
Federal income tax	100	100	97
Provincial income tax	100	100	97
Provincial mining tax and royalty	100	100	73
Overall	100	100	88

Tax Option 3	Tax Option 4	Tax Option 5	Tax Option 6
19	19	19	20
172	172	172	165
101	101	101	97
161	159	139	151
434	432	412	413
45	45	45	43
27	27	27	26
43	42	37	39
115	114	109	108
23	23	23	24
14	14	14	14
23	22	20	21
60	59	57	59
39	40	41	40
61	60	59	60
100	100	100	97
100	100	100	97
100	98	87	91
100	99	95	95

Table 35. Manitoba mining taxation options: after-tax cash flow characteristics and expected values for an economic deposit, at lower-limit prices

Characteristic	Base Case	Tax Option 1	Tax Option 2
Total exploration expenditures ($ million)	1,064	1,064	1,064
Number of economic deposits	3	3	3
Time periods (years)			
Exploration	59	59	59
Development (maximum)	3	35	3
Production (maximum)	47	47	47
Overall time period	108	108	108
Undiscounted values ($ million)			
Revenue	2,506	2,506	2,506
Less: Exploration expenditure	355	355	355
Development capital cost	102	102	102
Production cost	1,671	1,671	1,671
Net tax payments	170	140	154
Cash flow	208	238	224
Economic indicators – start of development			
Net present value ($ million)	46	46	56
Rate of return (percent)	15	15	16
Economic indicators – start of exploration			
Average return (R, $ million)	0	0	0
Average exploration expenditure (E, $ million)	25	19	25
Expected value (EV, $ million)	– 25	– 19	– 25
Expected rate of return (percent)	2	2	2

Tax Option 3	Tax Option 4	Tax Option 5	Tax Option 6
1,064	1,064	1,064	1,064
3	3	3	3
59	59	59	59
3	3	3	3
47	47	47	47
108	108	108	108
2,506	2,506	2,506	2,506
355	355	355	355
102	102	102	102
1,671	1,671	1,671	1,671
134	167	154	163
244	211	224	215
46	48	49	51
15	15	15	16
1	0	0	0
18	25	25	25
- 17	- 25	- 25	- 25
2	2	2	2

Table 36. Manitoba mining taxation options: after-tax cash flow characteristics and expected values for an economic deposit, at upper-limit prices

Characteristic	Base Case	Tax Option 1	Tax Option 2
Total exploration expenditures ($ million)	1,064	1,064	1,064
Number of economic deposits	41	41	41
Time periods (years)			
Exploration	4	4	4
Development (maximum)	5	5	5
Production (maximum)	48	48	48
Overall time period	53	53	53
Undiscounted values ($ million)			
Revenue	1,743	1,743	1,743
Less: Exploration expenditure	30	30	30
Development capital cost	70	70	70
Production cost	531	531	531
Net tax payments	607	605	581
Cash flow	505	507	531
Economic indicators – start of development			
Net present value ($ million)	128	128	146
Rate of return (percent)	30	30	35
Economic indicators – start of exploration			
Average return (R, $ million)	92	91	104
Average exploration expenditure (E, $ million)	7	5	7
Expected value (EV, $ million)	85	86	97
Expected rate of return (percent)	23	24	26

Tax Option 3	Tax Option 4	Tax Option 5	Tax Option 6
1,064	1,064	1,064	1,064
41	41	41	41
4	4	4	4
5	5	5	5
48	48	48	48
53	53	53	53
1,743	1,743	1,743	1,743
30	30	30	30
70	70	70	70
531	531	531	531
605	606	574	604
507	506	538	508
128	129	138	131
30	30	31	31
92	92	98	94
5	7	7	7
87	85	91	87
25	23	24	24

Table 37. Manitoba mining taxation options: taxation criteria from the start of exploration, at upper-limit prices

Criterion	Base Case	Tax Option 1	Tax Option 2
Number of economic deposits	41	41	41
Net undiscounted tax revenues ($ million)			
Federal income tax	240	240	240
Provincial income tax	141	141	141
Provincial mining tax and royalty	226	224	200
Total	607	605	581
Net tax revenues discounted at 8 percent ($ million)			
Federal income tax	44	44	44
Provincial income tax	26	26	26
Provincial mining tax and royalty	44	42	32
Total	114	112	102
Effective tax rates (percent)			
Federal income tax	22	22	22
Provincial income tax	13	13	13
Provincial mining tax and royalty	22	21	16
Total	57	56	51
Government tax shares (percent)			
Federal government	39	39	43
Provincial government	61	61	57
Comparative tax levels (Manitoba = 100)			
Federal income tax	100	100	100
Provincial income tax	100	100	100
Provincial mining tax and royalty	100	96	72
Overall	100	98	89

Tax Option 3	Tax Option 4	Tax Option 5	Tax Option 6
41	41	41	41
240	240	240	240
141	141	141	141
224	225	193	223
605	606	574	604
44	44	44	44
26	26	26	26
42	43	37	42
112	113	107	112
22	22	22	22
13	13	13	13
21	22	19	21
56	57	54	56
39	39	41	39
61	61	59	61
100	100	100	100
100	100	100	100
95	98	85	95
98	99	94	98

Table 38. Manitoba mining taxation options: taxation criteria from the start of development, at lower-limit prices

Criterion	Base Case	Tax Option 1	Tax Option 2
Number of economic deposits	3	3	3
Net undiscounted tax revenues ($ million)			
Federal income tax	160	160	160
Provincial income tax	94	94	94
Provincial mining tax and royalty	149	149	133
Total	403	403	387
Net tax revenues discounted at 8 percent ($ million)			
Federal income tax	39	39	39
Provincial income tax	23	23	23
Provincial mining tax and royalty	38	38	28
Total	100	100	90
Effective tax rates (percent)			
Federal income tax	27	27	27
Provincial income tax	16	16	16
Provincial mining tax and royalty	26	26	19
Total	69	69	62
Government tax shares (percent)			
Federal government	39	39	43
Provincial government	61	61	57
Comparative tax levels (Manitoba = 100)			
Federal income tax	100	100	100
Provincial income tax	100	100	100
Provincial mining tax and royalty	100	100	73
Overall	100	100	90

Tax Option 3	Tax Option 4	Tax Option 5	Tax Option 6
3	3	3	3
160	160	160	160
94	94	94	94
149	146	133	142
403	400	387	396
39	39	39	39
23	23	23	23
38	36	34	33
100	98	96	95
27	27	27	27
16	16	16	16
26	24	24	22
69	67	66	65
39	40	40	41
61	60	60	59
100	100	100	100
100	100	100	100
100	95	91	87
100	98	96	95

Table 39. Manitoba mining taxation options: taxation criteria from the start of development, at upper-limit prices

Criterion	Base Case	Tax Option 1	Tax Option 2
Number of economic deposits	41	41	41
Net undiscounted tax revenues ($ million)			
Federal income tax	247	247	247
Provincial income tax	146	146	146
Provincial mining tax and royalty	231	231	205
Total	624	624	598
Net tax revenues discounted at 8 percent ($ million)			
Federal income tax	70	70	70
Provincial income tax	41	41	41
Provincial mining tax and royalty	68	68	50
Total	179	179	161
Effective tax rates (percent)			
Federal income tax	23	23	23
Provincial income tax	13	13	13
Provincial mining tax and royalty	22	22	16
Total	58	58	52
Government tax shares (percent)			
Federal government	39	39	44
Provincial government	61	61	56
Comparative tax levels (Manitoba = 100)			
Federal income tax	100	100	100
Provincial income tax	100	100	100
Provincial mining tax and royalty	100	100	74
Overall	100	100	90

Tax Option 3	Tax Option 4	Tax Option 5	Tax Option 6
41	41	41	41
247	247	247	247
146	146	146	146
231	230	198	228
624	623	591	621
70	70	70	70
41	41	41	41
68	66	58	65
179	177	169	176
23	23	23	23
13	13	13	13
22	22	19	21
58	58	55	57
39	40	41	40
61	60	59	60
100	100	106	100
100	100	100	100
100	98	86	96
100	99	95	98

Appendix XI

After-Tax Evaluation Results: Proposed Manitoba Mining Tax System

Table 40. Manitoba mining taxation proposed systems: after-tax cash results as a function of metal price

Characteristic	Lower-Limit	Expected	Upper-Limit
Total exploration expenditures ($ million)	1,064	1,064	1,064
Number of economic deposits	3	20	41
Time periods (years)			
Exploration	59	9	4
Development (maximum)	3	5	5
Production (maximum)	47	48	48
Overall time period	107	58	53
Undiscounted values ($ million)			
Revenue	2,506	1,456	1,743
Less: Exploration expenditure	355	53	30
Development capital cost	102	59	70
Production cost	1,671	638	531
Net tax payments	133	372	598
Cash flow	245	365	514
Economic indicators – start of development			
Net present value ($ million)	52	77	134
Rate of return (percent)	16	25	31
Economic indicators – start of exploration			
Average return (R, $ million)	1	39	96
Average exploration expenditure (E, $ million)	18	9	5
Expected value (EV, $ million)	– 17	30	91
Expected rate of return (percent)	2	15	26

Table 41. Manitoba mining taxation proposed system: taxation criteria from the start of exploration

Criterion	Expected	Upper Limit
Number of economic deposits	20	41
Net undiscounted tax revenues ($ million)		
Federal income tax	150	240
Provincial income tax	88	141
Provincial mining tax and royalty	134	217
Total	372	598
Net tax revenues discounted at 8 percent ($ million)		
Federal income tax	11	44
Provincial income tax	7	26
Provincial mining tax and royalty	8	38
Total	26	108
Effective tax rates (percent)		
Federal income tax	20	22
Provincial income tax	12	13
Provincial mining tax and royalty	14	19
Total	46	54
Government tax shares (percent)		
Federal government	40	41
Provincial government	60	59
Comparative tax levels (Manitoba = 100)		
Federal income tax	104	100
Provincial income tax	104	100
Provincial mining tax and royalty	59	83
Overall	84	94

Table 42. Manitoba mining taxation proposed system: taxation criteria from the start of development

Criterion	Lower-Limit	Expected	Upper-Limit
Number of economic deposits	3	20	41
Net undiscounted tax revenues ($ million)			
Federal income tax	160	165	247
Provincial income tax	95	97	146
Provincial mining tax and royalty	147	150	225
Total	402	412	618
Net tax revenues discounted at 8 percent ($ million)			
Federal income tax	39	44	70
Provincial income tax	23	26	41
Provincial mining tax and royalty	32	37	62
Total	94	107	173
Effective tax rates (percent)			
Federal income tax	27	24	23
Provincial income tax	16	14	14
Provincial mining tax and royalty	22	20	20
Total	65	58	57
Government tax shares (percent)			
Federal government	41	41	41
Provincial government	59	59	59
Comparative tax levels (Manitoba = 100)			
Federal income tax	100	97	100
Provincial income tax	100	97	100
Provincial mining tax and royalty	85	87	91
Overall	94	93	97

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